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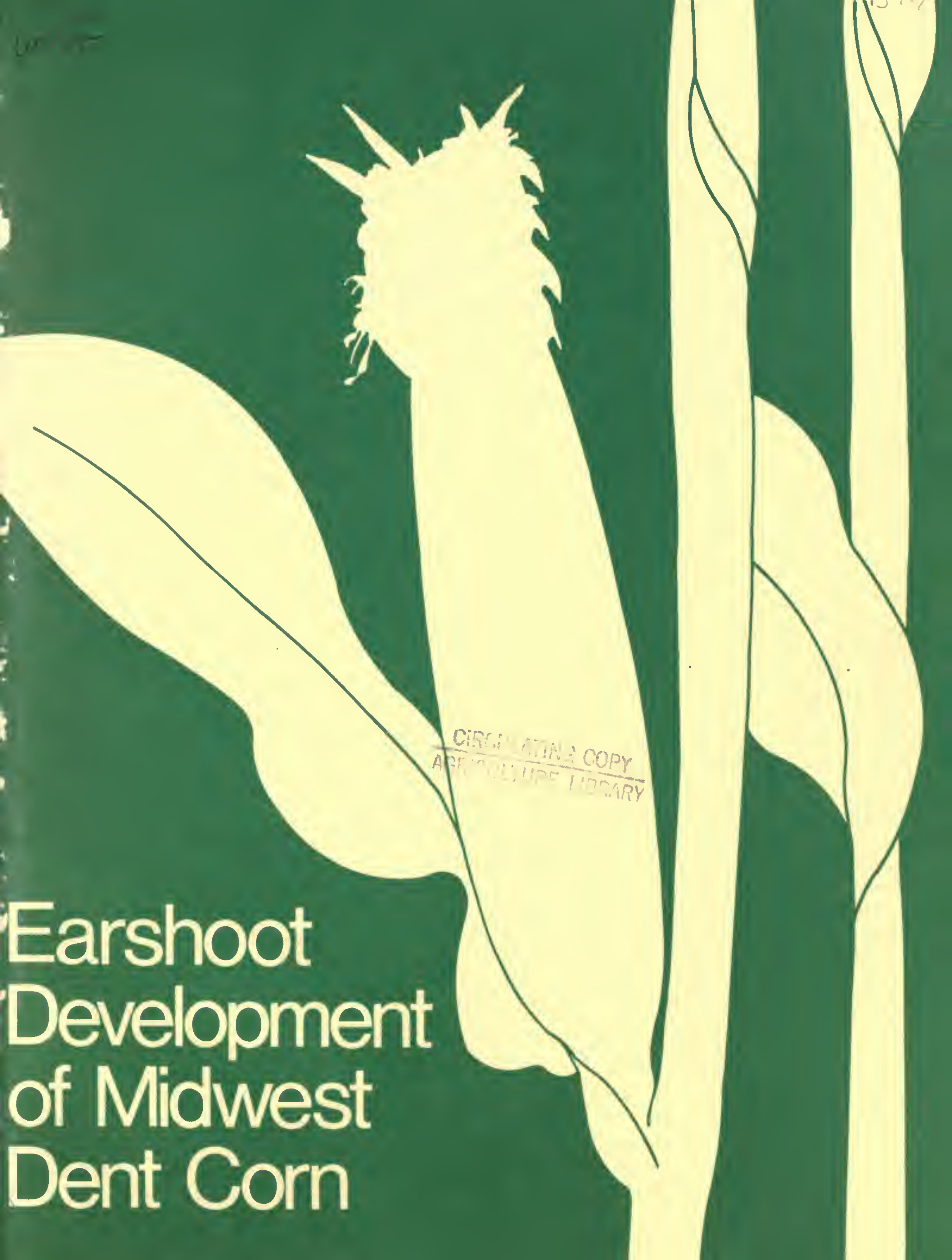

Earshoot Development of Midwest Dent Corn

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Earshoot Development of Midwest Dent Corn (*Zea mays* L.)

E. B. Earley, J. C. Lyons, E. Inselberg, R. H. Maier, and E. R. Leng

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Table 1. *Effects of a Combination of Gibberellic Acid and Tween-20 on Ear Height of Corn Plants, 1960*

Milligrams per plant		Age of plants[a]	No. of leaves per plant	No. of nodes per plant		Length of internode (inches)		Height of plant (inches)			Dry grain per plant (grams)
Gibberellic acid	Tween-20			To top ear node	Above top ear node	Below top ear	Above top ear	To top ear node	Above top ear node	From ground to base of flag leaf	
						Hy2 x Oh7					
0	0	..	...	7.9	6.7	5.9	5.0	40.7	38.5	79.2	357
.5	1.2	17	4.25	2.7	12.2	1.3	5.3	6.5	64.7	71.2	50
1.0	2.4	17	4.25	4.0	11.5	2.1	5.3	11.3	62.3	73.7	99
2.0	4.8	17	4.25	5.2	9.8	2.2	5.0	12.6	51.8	64.4	130
	average:	17	4.25	4.0	11.2	1.9	5.2	10.0	60.1	70.1	91
.5	1.2	20	5.25	6.4	9.1	4.3	6.1	23.1	62.3	85.4	325
1.0	2.4	20	5.25	6.5	9.2	4.2	5.9	23.7	60.3	84.0	288
2.0	4.8	20	5	6.3	9.0	4.1	6.2	21.7	63.1	84.8	284
	average:	20	5.1	6.4	9.1	4.2	6.1	22.8	62.0	84.8	300
.5	1.2	23	6.25	7.5	7.0	4.7	5.8	30.4	46.7	77.1	328
1.0	2.4	23	6	7.3	7.6	4.6	5.8	29.1	49.6	78.7	364
2.0	4.8	23	6	6.8	7.5	4.3	6.1	24.8	51.7	76.5	342
	average:	23	6.1	7.2	7.3	4.6	5.9	28.4	49.1	77.5	344
						WF9 x Oh7					
0	0	..	...	7.5	6.0	5.6	6.3	36.5	44.2	80.7	292
.5	1.2	17	4.3	5.2	9.0	2.8	6.3	13.2	63.7	76.9	169
1.0	2.4	17	4.3	4.0	10.7	2.2	5.2	10.0	58.0	68.0	95
2.0	4.8	17	4.3	3.9	10.3	2.5	5.3	12.0	57.3	69.3	112
	average:	17	4.3	4.3	10.1	2.5	5.6	11.8	59.2	71.4	123
.5	1.2	20	5.5	7.1	6.7	4.5	6.9	27.3	52.1	79.4	258
1.0	2.4	20	5.5	5.7	8.1	4.0	6.6	19.0	60.1	79.1	234
2.0	4.8	20	5.5	5.9	7.9	3.8	6.5	18.7	57.3	76.0	211
	average:	20	5.5	6.2	7.6	4.1	6.6	21.5	56.6	78.1	233
.5	1.2	23	6.5	7.3	7.4	4.4	6.3	27.4	52.7	80.1	299
1.0	2.4	23	6.75	7.0	6.9	4.4	6.6	26.5	51.6	78.1	284
2.0	4.8	23	6.5	6.7	7.3	4.4	6.5	25.3	54.0	79.3	300
	average:	23	6.6	7.0	7.2	4.4	6.5	26.4	52.7	79.1	294

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[a] Days from date of planting (5/24/60) to date of treatment.

Yield of corn grain per acre is determined by the number of plants and by the number and size of ears (pistillate inflorescences with grain) per plant. One or more of the six to eight earshoots — pistillate inflorescences with no grain — usually develop into ears, depending upon the hybrid, rate of planting, and cultural conditions (soil fertility, water, light, temperature, and so on). Earshoots that are normally capable of producing grain are called "functional"; those normally incapable of producing grain are called "nonfunctional."

In searching for methods of further increasing grain yields, the following factors that affect the number and size of ears per plant were investigated: rate of planting, earshoot coverage and removal, simultaneous and different times of pollination of earshoots, amount of sunlight reaching the plants, and chemical treatment of several parts of the plants.

VEGETATIVE BUD DEVELOPMENT

Morphological studies of the development of floral structures of corn plants have been published by Martin and Hershey (1934), Sharman (1942), Bonnett (1948, 1953), and Kiesselbach (1949). Generally, each of the lower eight or so nodes of the corn plant has an axillary vegetative bud that is initiated acropetally (from the base of the plant upward) and transformed into an earshoot basipetally (from the top bud downward) at intervals of about one-half to four days. The earshoots develop into one or more functional earshoots always basipetally (Sass and Loeffel, 1959; Sass, 1960 and 1962; Siemer, 1964; Siemer *et al.,* 1969). The yield of grain per plant is not limited by lack of potential ears but by failure of one or more of the earshoots to develop into sizable ears.

It is not known why the axillary buds usually stop forming at the eighth node from the base of the plant rather than at the top node, but the explanation seems to be closely associated with the initial elongation of the apex of the main stalk and with tassel differentiation (Bonnett, 1948; Leng, 1951). This observation is strengthened by data in Table 1 and by the plants illustrated in Figure 1. Applying gibberellic acid and Tween-20 (polyoxyethylene-sorbitan-monolaurate, a wetting agent) to plants before normal elongation of the stem apex occurred caused the plants to stop forming axillary buds.[1] Presumably, gibberellic acid initiated elongation of the stem apex sooner than normal, causing vegetative buds to stop forming in the axils of leaves that subsequently developed. As a result, ears developed on treated plants from lower axillary buds than on untreated plants. There was no sign of vegetative bud development in the axils of the leaves above the bud that developed into the first (top) ear. Further experiments with growth-regulating substances are described in the appendix.

It should be pointed out that, although the literature indicates the presence of an axillary vegetative bud at each of the lower eight or so nodes of the corn plant, extensive field work with L317 x R4 disclosed that many plants did not produce a vegetative bud in the axil of each of the lower leaves. At such points, consequently, there was no earshoot development and no groove in the corresponding internode (Fig. 2). Occasionally, moreover, the first (top) axillary bud produced only the prophyll, which appeared to be the beginning of a functional earshoot; in these few cases the first ear developed from the second axillary bud rather than from the first axillary bud. Figure 3 shows corn plants with prophylls at the first node above the top ear. Their origin and structure have been reported by Kiesselbach (1949), Anderson (1950), Bonnett (1953), Collins (1963), and Sass and Loeffel (1959).

SHANK EARS

Each node of the shank (connecting tissue between stalk and ear) has a vegetative bud identical to the buds in the axils of lower leaves of the main plant. Some hybrids, including WF9 x Hy2, have a greater tendency than other hybrids to develop sizable earshoots from axillary buds of the first and second shanks (Fig. 4). Usually, in order for the plant to produce sizable ears on the shank, the first earshoot has to be removed, covered, or partially damaged around silking time. Initiation of axillary buds and the development of earshoots on shanks have also been reported by Freeman (1940).

PATTERN OF EARSHOOT DEVELOPMENT

The basipetal pattern of earshoot development (Fig. 2 and 5) and the production of grain by the upper nonfunctional earshoots when functional earshoots are removed (see pages 11-22) suggest that growth-promoting substances are synthesized in the upper part of the plant (probably in the leaves) and move down the stalk into the earshoots. The first earshoot is seemingly in the most favorable position to receive growth-promoting substances if the plants possess no mechanism for distributing these substances to the lower earshoots. The basipetal pattern is emphasized by the decrease in grain yield per ear from the top ear downward, as reflected in the data for check plants reported in this publication and in results reported by Krantz and Chandler (1954), Bauman (1960), and Collins and Russell (1965).

The pattern of earshoot development of corn plants is apparently similar to fruit set in the inflorescence of tomato plants, about which Gustafson (1946) stated, "Flower buds formed first in an inflorescence of the tomato plant have more hormone and are more likely to set fruit than those formed later. The second, third, and fourth flower set have progressively less hormone and less chance of setting fruit."

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[1] All experiments described in this bulletin were conducted in fertile soil on the Agronomy South Farm of the University of Illinois at Urbana-Champaign.

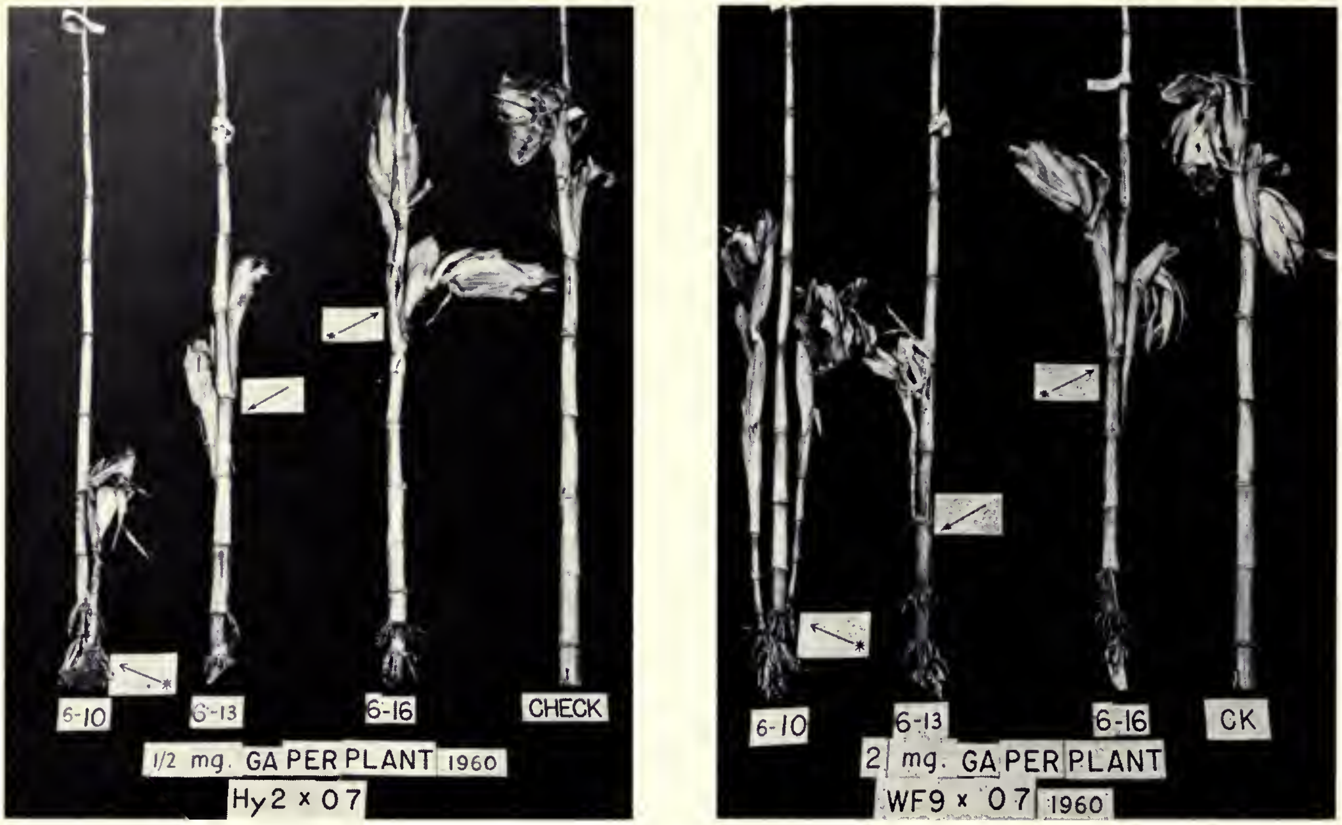

Figure 1. Effects of a combination of gibberellic acid and Tween-20 (polyoxyethylene-sorbitan-monolaurate) on the height at which ears are produced on corn plants. Dates given are dates of application.

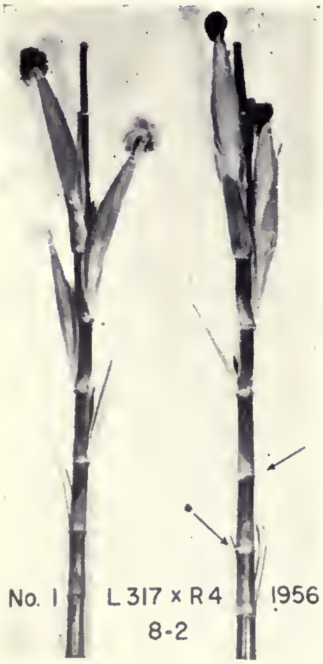

Figure 2. Pattern of earshoot development. Upper arrow indicates absence of axillary bud at node on the plant at right.

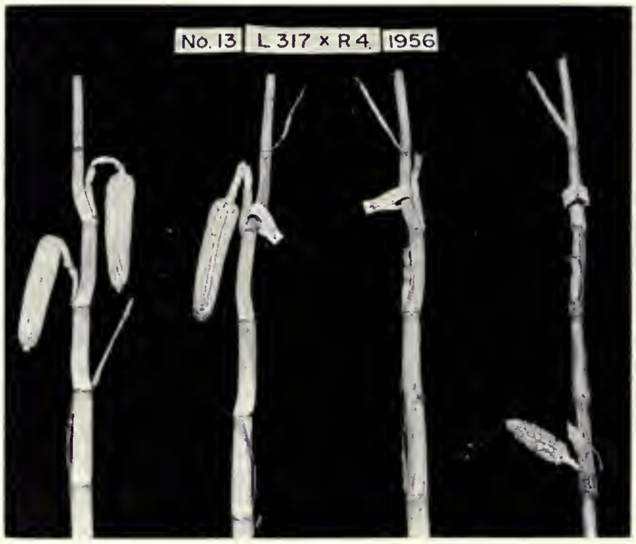

Figure 3. Three plants at right show prophylls at first node above top ear. The plant at the left is the normal check. The two plants at far right have had the two upper earshoots removed.

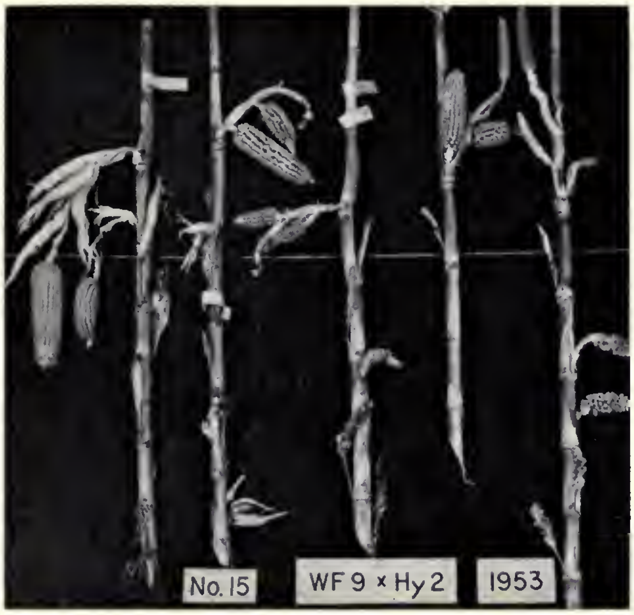

Figure 4. The plant on the left shows fully developed earshoots on the shank of the first ear. The other plants show shank ears formed after the primary earshoots had been removed or covered before silking.

The developmental patterns of earshoots of WF9 x C103 (one ear per plant) and L317 x R4 (two ears per plant) are shown in Figure 5 (Inselberg, 1956). The seeds were planted May 21, 1954, and thinned to one plant per 40″ by 40″ on June 28. By July 19 (59 days after planting), all of the above-ground axillary vegetative buds had been transformed into visible earshoots. From this time until the plants reached full size, the two upper earshoots of both hybrids developed at a much faster rate than the lower ones. Moreover, the two upper earshoots of the two-ear hybrid developed more nearly at the same rate than those of the single-ear hybrid.

At this low rate of planting, the lower nonfunctional earshoots of both hybrids ranged from very small with no silks showing to silks about the size of the functional ones. The second earshoots of plants of WF9 x C103 and the third and occasionally the fourth earshoots of plants of L317 x R4 produced silks but seldom produced grain. However, the lower nonfunctional earshoots of these and other hybrids were maintained in a potentially functional condition until about eight days after silking of the first earshoot (see pages 16-20 and Figs. 11-13).

Quantitative studies of the rate of development of upper earshoots of several single-cross corn hybrids during the two-week period before silking of the top earshoot

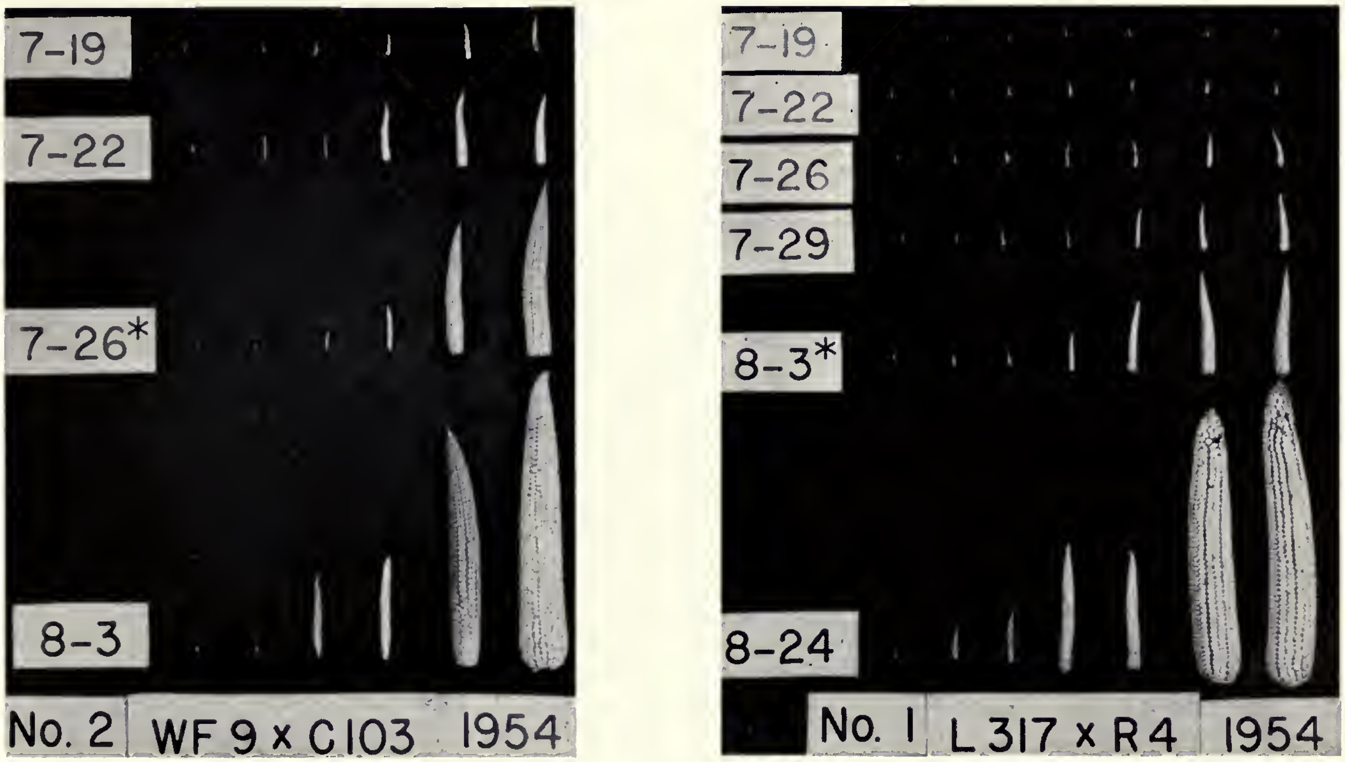

Figure 5. Developmental pattern of earshoots from plants of WF9 x C103 and L317 x R4; the top earshoot is at the right end of each row. Asterisks designate approximate silking date of top earshoot.

have been reported by Collins (1963) and by Collins and Russell (1965). Data on earshoot development of corn have also been presented by Freeman (1940), Kiesselbach (1949), Sass and Loeffel (1959), Sass (1960), and Hanway (1966). These findings are in general agreement with the developmental pattern of earshoots of one- and two-ear hybrids that is presented in Figure 5.

Under conditions of low fertility or at a high rate of planting, some plants of most hybrids fail to produce even one ear (Fig. 6). Normally, earshoots that become functional do so before silk emergence (Kiesselbach, 1922). Sass and Loeffel (1959) state that the failure of plants to produce ears (barrenness) "is the result of failure of silk emergence during the pollen-shedding period, rather than the failure of formation of floral organs." However, first earshoots that silk as much as 10 days later than the check plants, 3 or 4 days after the pollen-shedding period, may be functional (Figure 17, page 23, shows the results of hand-pollinating first earshoots that silked late because of shading).

Data presented by Siemer (1964) and by Siemer *et al.* (1969) show that several inbreds and hybrids differ considerably in the number of days between initiation of the first and second earshoots and of the first and third earshoots. Average time between initiation of first and second earshoots of inbreds ranged from 0 days for M14 to 4.7 days for C103; for hybrids the interval ranged from 0.4 days for B14 x Oh43 to 2.5 for Hy2 x C103.

Unfortunately, Siemer (1964) did not record the number of ears per plant in 1962, and the data for 1963 were insufficient to show whether the time between initiation of the first and lower earshoots on each plant correlated with the pattern of earshoot development and the number of ears per plant. It would be desirable, therefore, to determine the interval of time between initiation of the first and lower earshoots and the number of ears per plant for inbreds and corresponding hybrids when grown one plant per hill at 4,000, 8,000, 12,000, 16,000, and 20,000 plants per acre. This would help determine how rate of planting, genetics, and cultural conditions (soil fertility, water, light, and so forth) interact to affect the interval of time between initiation of the first and the lower earshoots. It would also help explain the relationship between that interval of time, the pattern of earshoot development, and the number of ears per plant.

EFFECTS OF RATE OF PLANTING

The effect of three rates of planting on the number of ears per plant of hybrid L317 x R4 are reported in Table 2. Figure 6 illustrates the effect of rate of planting on the number and size of ears per plant for Hy2 x Oh7 and WF9 x C103. Similar results, which also show the large influence of rate of planting, have been reported by Brown and Garrison (1923), Long (1953), Krantz and Chandler (1954), Lang *et al.* (1956), Dungan *et al.* (1958), Zuber *et al.* (1960), Collins and Russell (1965), Russell and Teich (1967), and Brown *et al.* (1970).

The data of Collins and Russell illustrate the interaction of rate of planting and genetics of one-ear x two-ear hybrids and two-ear x two-ear hybrids on the number of ears per plant. The percentages of plants with two ears when one-ear x two-ear hybrids were grown at 8,000, 12,000, and 16,000 plants per acre were 17.5, 4.4, and 0.6, respectively; the corresponding percentages for two-ear x two-ear hybrids were 85.6, 39.7, and 2.8. Such

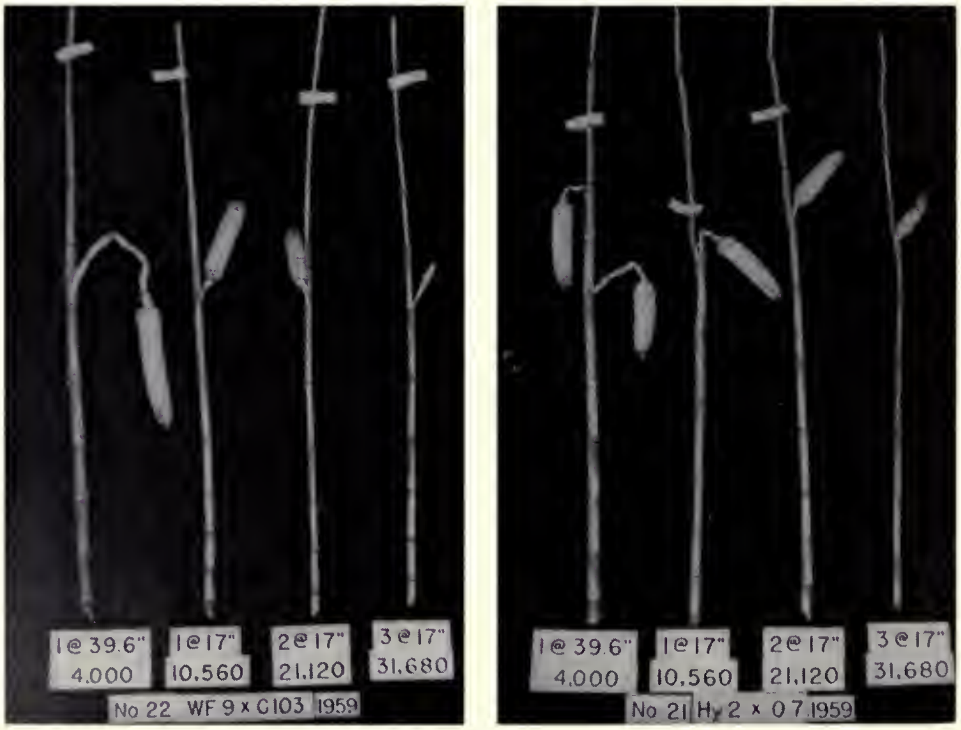

Figure 6. Effects of rate of planting on number and size of ears per plant. Upper numbers give plants per hill and hill size; lower numbers are plants per acre.

Table 2. Effect of Rate of Planting on Number of Ears per Plant of L317 x R4, 1955

Number of plants with	Rate of planting 1 per hill (80" x 80")	 1 per hill (40" x 40")	 3 per hill (40" x 40")
One ear	0	0	44
Two ears	13	103	8
Three ears	66	1	0
Four ears	0	0	0

results underline the necessity of studying inbreds and hybrids over a range of planting rates and cultural conditions; only so can the interaction of these factors on the interval of time between initiation of earshoots and the number of ears per plant be clarified.

Decreasing the land area per plant by increasing the rate of planting decreases the number and size of ears per plant of multiple-ear hybrids and decreases the size of ears on single-ear hybrids, even under favorable cultural conditions. These decreases are ascribed largely to reduced amounts of light per plant, reduced stalk diameter (Eisele, 1938), reduced leaf area (Eisele, 1938; Earley, 1961; Nunez and Kamprath, 1969; Brown *et al.*, 1970), and probably reduced amounts of growth-promoting substances. The interval of time, moreover, between initiation of the first and the lower earshoots per plant is probably increased with decreased land area per plant.

On the other hand, the beneficial effects of large land areas per plant are associated with more light per plant, which aids production of maximum leaf area and stalk diameter; large leaf areas, in turn, intercept more light and synthesize more of the materials needed for ear production. Spacing the plants more widely also probably decreases the interval between initiation of earshoots.

It is interesting to note that the effects of rate of planting on the number and size of ears per plant are much the same as from shading of plants (see pages 22-24). The decrease in number and size of ears per plant when plants are shaded apparently substantiates the statement of Thimann and Skoog (1934) and Avery *et al.* (1937b) that plants produce growth substances only in the presence of light.

Table 3. Genetic Influence on Number of Mature Ears per Plant of Four Single-Cross Hybrids, 1953

Number of plants with	WF9 x C103	L317 x R4	2110 x K64	2110 x 540
One ear	27	5	1	0
Two ears	8	315	49	13
Three ears	0	4	103	27
Four ears	0	0	25	23
Five ears	0	0	0	5
Six ears	0	0	0	1

GENETIC INFLUENCE

Hybrids shown in Figure 7 were grown at the rate of one plant per 40″ x 40″ hill (4,000 plants per acre) in 1953. Tillers were removed at the four-leaf stage. The number of ears per plant for each hybrid is given in Table 3. Apparently, these hybrids have a genetically controlled mechanism for making possible the production of one to six ears per plant. A similar conclusion was reached by Collins and Russell (1965), who reported that, at 8,000 plants per acre, "all single crosses of the two-ear inbreds produced some harvestable second ears, which suggests that a homeostatic mechanism exists in the two-ear x two-ear crosses that was not present in the one-ear x one-ear crosses and that was not present to as great an extent in the one-ear x two-ear crosses. Second-ear development is proposed as a mechanism by which Corn Belt maize plants can exhibit developmental homeostasis."

At 16,000 plants per acre, Leng (1954) as well as Collins and Russell observed no consistent genetic influence on the number of ears per plant that had been observed at lower rates of planting.

The maximum number of ears per plant that a given hybrid can produce is genetically controlled. The expression of the genetic potential for the number of ears per plant depends upon many environmental factors, however, including water (Robins and Domingo, 1953; Howe and Rhoades, 1955; Denmead and Shaw, 1960; Gard *et al.*, 1961); light (Stinson and Moss, 1960; Earley *et al.*, 1966 and 1967; Pendleton *et al.*, 1967; Schmidt and Colville, 1967); and soil fertility and rate of planting (Long, 1953; Krantz and Chandler, 1954; Lang *et al.*, 1956; Zuber *et al.*, 1960). Therefore, genetic control of the number of ears per plant appears to be quantitative, not qualitative.

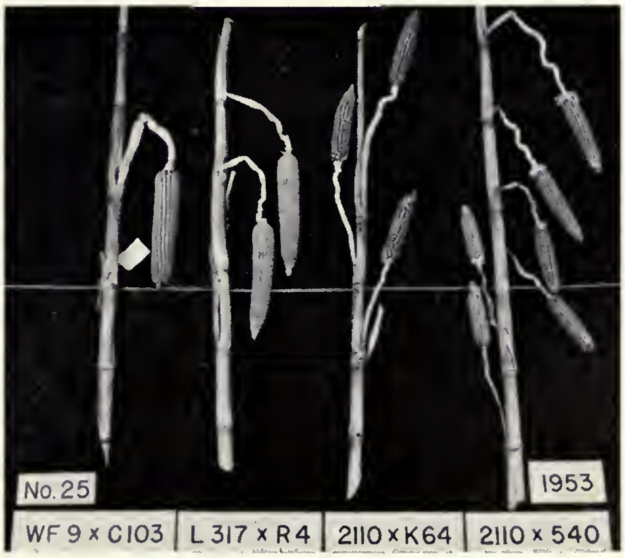

Figure 7. Genetic influence on number of ears per plant. These plants were grown at one plant per 40″ x 40″ hill.

SIMULTANEOUS POLLINATION OF ALL SILKING EARSHOOTS

As shown in Figure 5, the two upper earshoots of the two-ear hybrid L317 x R4 developed at more nearly the same rate than the two upper earshoots on the single-ear hybrid WF9 x C103. Moreover, the length of time between silking of the first and second earshoots of L317 x R4 was less than for WF9 x C103. It is quite likely, therefore, that the first and second earshoots of L317 x R4 were pollinated at more nearly the same time than were the first and second earshoots of WF9 x C103. This could perhaps account for the production of two ears per plant by L317 x R4 and one ear per plant by WF9 x C103. Should this supposition be correct, pollinating all earshoots on a given plant at the same time should thus enable all the earshoots to develop into ears.

On May 25, 1950, five hybrids were planted and grown at the rate of one plant per 40″ x 40″ hill (Lyons, 1952). All sizable earshoots on 10 plants of each hybrid were covered before silking. After six days of silking, all earshoots with silks were uncovered and the silks were clipped and pollinated as quickly as possible, beginning with the lowest silking earshoot on each plant.

Table 4. Average Number of Ears Produced per Plant When All Silking Earshoots Were Pollinated Naturally or Simultaneously, 1950

	Natural pollination		Simultaneous pollination	
Hybrid	Ear-shoots silking	Ears produced	Ear-shoots silking	Ears produced
2110 x 540	4.2	3.0	4.9	2.6
2110 x K64	3.1	2.1	2.9	2.1
L317 x W8	2.7	2.0	3.3	2.0
L317 x 540	2.7	2.0	3.0	2.0
L317 x R4	2.4	1.7	2.2	1.8

The results of simultaneous versus natural pollination, given in Table 4, show that pollinating several earshoots per plant at approximately the same time did not result in production of more ears than would result from natural pollination. Consequently, the length of time between natural pollination of earshoots per plant under field conditions appears not to be a factor in determining the number of ears per plant. Moreover, pollination *per se* neither stimulates elongation of earshoots nor converts nonfunctional earshoots into functional ones. Since not all silking earshoots per plant are functional, therefore, differences between functional and nonfunctional earshoots are more complex than previously thought.

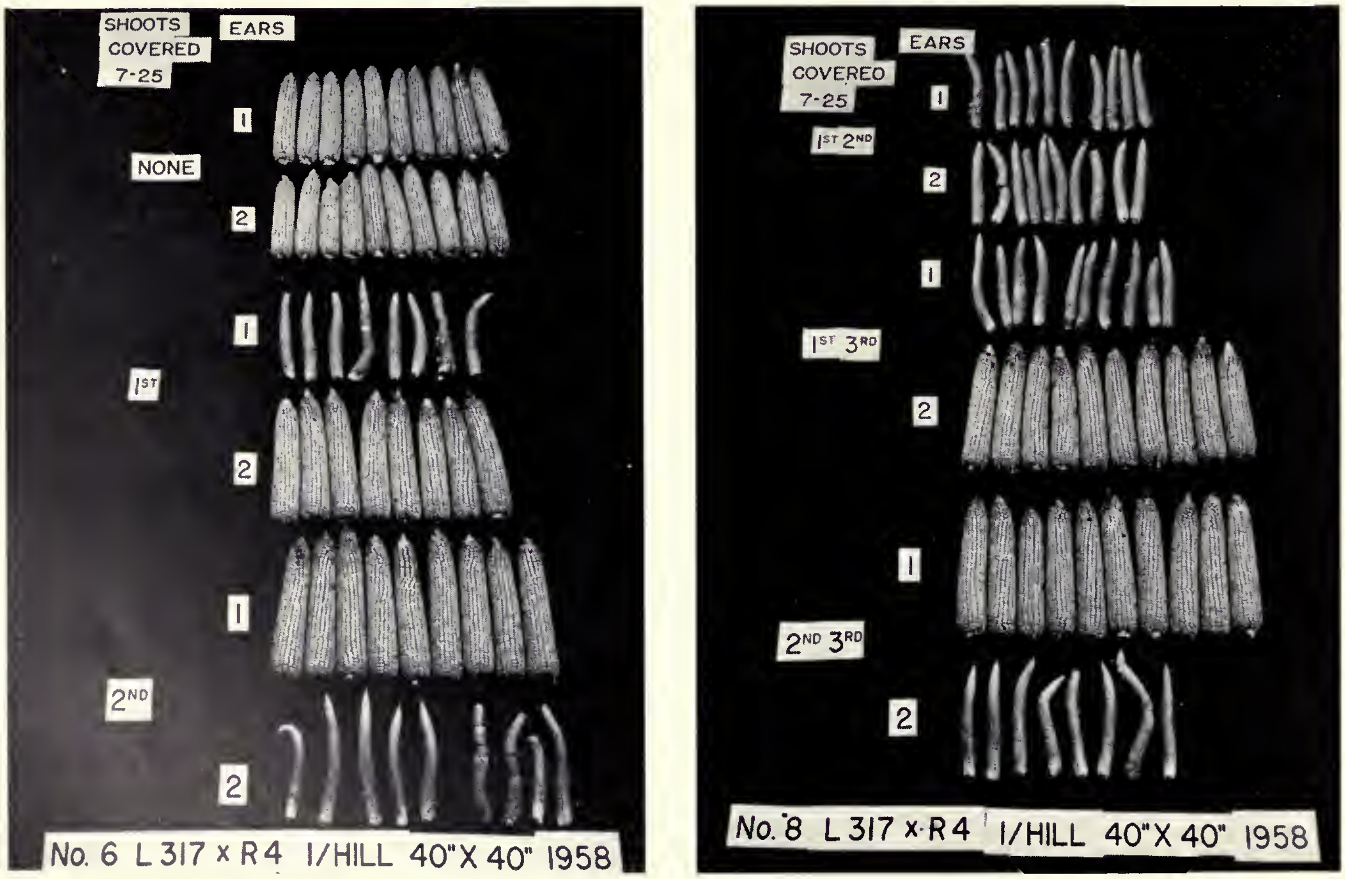

Figure 8. Effects of covering certain earshoots of L317 x R4 (a two-ear hybrid) before silking of the first earshoots.

COVERED EARSHOOTS

In order to discover whether some nonfunctional earshoots could become functional if the functional earshoots were prevented from being pollinated, various earshoots were covered before silking and the effects on all earshoots were recorded. Figure 8 shows cobs and ears of L317 x R4 used in these experiments, and Tables 5 and 6 present the data on all varieties so studied.

When functional earshoots were covered before silking, some of the nonfunctional earshoots developed into ears. The specific response of the nonfunctional earshoots depended upon hybrid, rate of planting, and seasonal and cultural conditions. The greatest response was from WF9 x M14 (Table 6), but the stimulation of its lower nonfunctional earshoots was associated with the failure of its second (nonfunctional) earshoots to develop into functional earshoots.

Covering either the first (functional) or the second (functional) earshoot of L317 x R4 increased the grain yield of the uncovered functional earshoot more than covering both functional earshoots increased the average grain yield of the third (nonfunctional) earshoot (Table 5). Apparently, the third (nonfunctional) earshoot received stimulation only when all functional earshoots were prevented from producing grain. Covering nonfunctional earshoots had no stimulatory effect on the growth and grain yield of functional ones. Collins and Russell (1965) reported earshoot coverage results similar to some of the data given here.

Covering earshoots of corn plants before silking had no adverse influence on their normal morphological development but did significantly prevent continued increases in dry weight of functional earshoots of L317 x R4, particularly when only one of the two functional earshoots was covered and the other pollinated. The uncovered pollinated earshoot, whether the first (functional) or the second (functional), showed increased grain yield, weight per 100 kernels, and weight and size of cob, compared to the corresponding ears of the check plants (Table 5). When pollination of the first (functional) earshoot was prevented by covering, therefore, some of the growth-promoting substances and nutrients that were normally transported into that earshoot after pollination were translocated into the second (functional) pollinated earshoot — and vice versa.

Consequently, pollination of functional earshoots has a positive effect on translocation of growth-promoting substances and nutrients from the plant into the ear — primarily into the grain. Pollination of nonfunctional earshoots apparently has no effect on translocation of growth-promoting substances or nutrients into them or into their fertilized ovules, since neither grow.

REMOVAL OF EARSHOOTS BEFORE SILKING

Since covering functional earshoots before silking produced a relatively slight and unpredictable stimulatory effect on the development of the nonfunctional earshoots, it was decided to find out what effect removal of functional earshoots before silking would have on the development of the nonfunctional earshoots. Data from this series of experiments are presented in Tables 7, 8, and 9.

Removal of either the first (functional) or second (functional) earshoot of L317 x R4 before silking resulted in a greater increase in length and weight per cob and in yield of grain and weight per 100 kernels of the other functional ear than the corresponding ears of the check plants had (Table 7). Moreover, removal of the first (functional) earshoot stimulated more grain production by the third (nonfunctional) earshoot than did removal of the second (functional) earshoot. Removal of the first and second (functional) earshoots stimulated grain production by the third and some of the fourth and fifth (nonfunctional) earshoots. Removal of the first and second (functional) and the third (nonfunctional) earshoots stimulated grain production by the fourth and some of the fifth and sixth (nonfunctional) earshoots. Removal of the third, fourth, and fifth (nonfunctional) earshoots had no effect on the grain yield of the first and second (functional) earshoots. Ears from this experiment are shown in Figure 9.

The effect of removing certain earshoots before silking of the first earshoots was studied for several other hybrids, also planted in 40″ x 40″ hills (Table 8). Removing the first (functional) earshoot increased grain production by the second (functional) earshoot. Removing the first and second (functional) earshoots initiated grain production in the third (nonfunctional) earshoots and in some of the fourth, fifth, and sixth (nonfunctional) earshoots.

Removing certain earshoots before silking of the first earshoot of WF9 x M14, a single-ear hybrid grown at one plant per 40″ x 12″ hill, affected the grain production of the remaining earshoots, as shown in Table 9 and Figure 10. Removing the first (functional) earshoot stimulated about as much grain production by the second (nonfunctional) earshoot as was produced by the first ears of the check plants. Removal of the first (functional) and second (nonfunctional) earshoots stimulated grain production by the third (nonfunctional) earshoot, and removal of the first three earshoots stimulated grain production by the fourth, fifth, and sixth (nonfunctional) earshoots. Removal of the second and third (nonfunctional) earshoots, however, had no stimulatory effect on the grain yield of the first (functional) earshoot.

Functional earshoots are dominant over the growth of all of the nonfunctional earshoots on a plant; however, removing the first (functional) earshoot of one-ear hybrids generally releases inhibition of only the second (nonfunctional) earshoot. The newly developing second earshoot apparently maintains dominance over the growth of the lower nonfunctional earshoots in a manner similar to the way upper axillary branches of decapitated dicotyledonous plants restrict the growth of lower axillary buds (according to Thimann and Skoog, 1934, and Mitchell, 1953).

Table 5. *Effects on Grain Production of Uncovered Earshoots of L317 x R4 When Certain Earshoots Were Covered Before Silking (One Plant per 40" x 40" Hill)*

	Date planted; earshoots covered														
	5/15/55			5/7/56		6/1/57		5/15/58							
	Check (none)	First	First and second	Check (none)	First and second	Check (none)	First and second	Check (none)	Third	First	First and third	Second	Second and third	First and second	First, second, and third
Number of plants.	104	111	115	50	50	9	9	26	9	9	10	10	11	10	9
Number of plants with silks on															
First earshoots . . .	104	111	115	50	50	9	9	26	9	9	10	10	11	10	9
Second earshoots. . .	104	111	115	50	50	9	9	26	9	9	10	10	11	10	9
Third earshoots . . .	86	93	102	22	22	4	6	9	7	3	4	5	3	5	4
Average silking date of															
First earshoots . . .	7/29	7/29	7/29	7/23	7/23	8/3	8/2	7/29	7/29	7/28	7/29	7/28	7/28	7/28	7/29
Second earshoots. . .	7/29	7/29	7/30	7/24	7/24	8/4	8/3	7/30	7/29	7/29	7/29	7/29	7/29	7/29	7/29
Third earshoots . . .	7/31	7/31	7/31	7/26	7/26	8/6	8/10	7/31	7/31	8/1	7/31	7/31	7/30	7/30	8/1
Number of plants with															
First ears.	104	0	0	50	0	9	0	26	9	0	0	10	11	0	0
Second ears	104	111	0	50	0	9	0	26	9	9	10	0	0	0	0
Third ears.	1	35	58	3	4	0	2	0	0	0	0	0	0	5	0
Average weight of dry grain (gm.)															
First ears.	[a]	[a]	[a]	[a]	[a]	173	0	186	179	0	0	262	255	0	0
Second ears	[a]	[a]	[a]	[a]	[a]	120	0	145	155	264	257	0	0	0	0
Third ears.	[a]	[a]	[a]	[a]	[a]	0	1	0	0	0	0	0	0	.7	0
Average weight per 100 dry kernels (gm.)															
First ears.	...	...	...	...	...	...	...	21.1	20.2	0	0	28.4	28.2	0	0
Second ears	...	...	...	...	...	...	...	18.9	19.6	27.2	28.7	0	0	0	0
Third ears.	...	...	...	...	...	...	...	0	0	0	0	0	0	33.7	0
Average weight per dry cob (gm.)															
First ears.	...	...	...	...	...	...	...	39.6	37.7	7.6	7.7	51.1	50.6	14.7	15.5
Second ears	...	...	...	...	...	...	...	29.4	32.0	49.4	49.4	5.5	5.8	12.4	13.0
Third ears.	...	...	...	...	...	...	...	0	0	0	0	0	0	.2	.2
Average length per dry cob (cm.)															
First ears.	...	...	...	...	...	...	...	22.7	22.2	19.0	18.9	24.7	24.5	20.0	20.1
Second ears	...	...	...	...	...	...	...	19.8	20.7	24.2	24.5	18.7	18.4	19.3	19.9
Third ears.	...	...	...	...	...	...	...	0	0	0	0	0	0	1.4	1.3
Average diameter per dry cob (cm.)															
First ears.	...	...	...	...	...	...	...	2.8	2.8	2.2	2.1	2.8	2.8	2.4	2.4
Second ears	...	...	...	...	...	...	...	2.8	2.8	2.8	2.9	1.9	2.2	2.2	2.2
Third ears.	...	...	...	...	...	...	...	0	0	0	0	0	0	.2	.2

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[a] Grain weights not taken.

Table 6. Effects on Grain Production of Uncovered Earshoots When Certain Earshoots Were Covered Before Silking (One Plant per 40" x 12" Hill)

	Hybrid; date planted; earshoots covered									
	L317 x R4, 6/1/57		WF9 x M14, 5/24/60				WF9 x M14, 5/18/61		Hy2 x Oh41, 5/18/61	
	Check (none)	First	Check (none)	First	Second	First and second	Check (none)	First	Check (none)	First
Number of plants.	10	12	10	10	10	10	22	20	22	22
Number of plants with silks on										
First earshoots	10	12	10	10	10	10	22	20	22	22
Second earshoots.	4	5	7	6	a	a	4	9	5	14
Third earshoots	0	0	0	1	0	a	0	13	0	7
Fourth earshoots.	0	0	0	0	0	0	0	17	0	2
Fifth earshoots	0	0	0	0	0	0	0	6	0	0
Sixth earshoots	0	0	0	0	0	0	0	0	0	0
Average silking date of										
First earshoots	8/2	8/1	7/28	a	7/28	..	7/27	7/28	7/31	7/30
Second earshoots.	8/3	8/3	7/30	7/30	a	..	7/28	8/10	8/2	8/9
Third earshoots	...	...	...	a	...	..	...	8/13	...	8/17
Fourth earshoots.	...	...	...	...	...	..	...	8/16	...	8/18
Fifth earshoots	...	...	...	...	...	..	...	8/15	...	...
Sixth earshoots	...	...	...	...	...	..	...	...	...	...
Number of plants with										
First ears.	10	0	10	0	10	0	22	0	22	0
Second ears	0	2	0	2	0	0	0	4	0	4
Third ears.	0	0	0	1	0	3	0	11	0	2
Fourth ears	0	0	0	0	0	0	0	11	0	0
Fifth ears.	0	0	0	0	0	0	0	3	0	0
Sixth ears.	0	0	0	0	0	0	0	0	0	0
Average weight of dry grain (gm.)										
First ears.	199	0	235	0	235	0	224	0	197	0
Second ears	0	29	0	25	0	0	0	9	0	6
Third ears.	0	0	0	7	0	4	0	28	0	1
Fourth ears	0	0	0	0	0	0	0	12	0	0
Fifth ears.	0	0	0	0	0	0	0	4	0	0
Sixth ears.	0	0	0	0	0	0	0	0	0	0

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[a] Data not obtained.

Table 7. Effects on Grain Production of Earshoots of L317 x R4 When Certain Earshoots Were Removed Before Silking of the First Earshoots, 1958 (One Plant per 40" x 40" Hill)

	Earshoots removed								
	Check (none)	Third	Third, fourth, and fifth	First	First and third	Second	Second and third	First and second	First, second, and third
Number of plants	26	9	10	7	10	9	9	9	7
Number of plants with silks on									
First earshoots	26	9	10	0	0	9	9	0	0
Second earshoots	26	9	10	7	10	0	0	0	0
Third earshoots	9	0	0	7	0	9	0	9	0
Fourth earshoots	0	0	0	0	4	2	1	6	7
Fifth earshoots	0	0	0	0	3	0	0	1	6
Average silking date of									
First earshoots	7/29	7/28	7/29	...	...	7/29	7/29	...	...
Second earshoots	7/30	7/29	7/29	7/29	7/29	...	...	...	...
Third earshoots	7/31	...	...	7/31	...	7/31	...	7/31	...
Fourth earshoots	...	...	...	...	8/2	7/30	8/2	8/4	8/2
Fifth earshoots	...	...	...	...	8/5	...	...	8/10	8/7
Number of plants with									
First ears	26	9	10	0	0	9	9	0	0
Second ears	26	9	10	7	10	0	0	0	0
Third ears	0	0	0	7	0	7	0	9	0
Fourth ears	0	0	0	0	3	1	1	5	7
Fifth ears	0	0	0	0	3	0	0	1	5
Average weight of dry grain (gm.)									
First ears	186	190	193	...	...	250	262	...	...
Second ears	145	149	149	210	267	...	...	...	...
Third ears	...	...	...	136	...	44	...	216	...
Fourth ears	...	...	...	...	14	13	6	45	211
Fifth ears	...	...	...	...	11	...	...	3	35[a]
Average weight per 100 dry kernels (gm.)									
First ears	21.1	21.6	21.6	...	...	26.7	28.5	...	...
Second ears	18.9	20.0	18.9	23.6	28.9	...	...	...	...
Third ears	...	...	...	20.4	...	24.0	...	28.4	...
Fourth ears	...	...	...	...	21.8	21.7	29.7	22.0	29.9
Fifth ears	...	...	...	...	23.0	...	...	29.2	29.6
Average weight per dry cob (gm.)									
First ears	39.6	38.8	40.5	...	...	49.6	53.7	...	...
Second ears	29.4	28.6	30.1	43.3	53.7	...	...	...	...
Third ears	...	...	...	26.2	...	8.6	...	48.0	...
Fourth ears	...	...	...	...	3.2	2.2	1.2	10.2	46.8
Fifth ears	...	...	...	...	3.2	...	...	1.1	13.9
Average length per dry cob (cm.)									
First ears	22.7	22.6	22.7	...	...	24.3	24.9	...	...
Second ears	19.8	20.0	20.0	22.9	25.5	...	...	...	...
Third ears	...	...	...	18.6	...	9.9	...	24.3	...
Fourth ears	...	...	...	...	10.7	15.6	12.7	18.1	24.0
Fifth ears	...	...	...	...	13.7	...	...	23.2	18.4
Average diameter per dry cob (cm.)									
First ears	2.8	2.8	2.8	...	...	2.8	2.9	...	...
Second ears	2.8	2.6	2.8	2.8	2.9	...	...	...	...
Third ears	...	...	...	2.7	...	2.1	...	2.9	...
Fourth ears	...	...	...	...	1.9	2.5	2.2	2.4	2.8
Fifth ears	...	...	...	...	2.2	...	...	1.9	2.3

[a] Includes 5.0 grams for the sixth ear.

Table 8. Effects on Grain Production of Earshoots When Certain Earshoots Were Removed Before Silking of the First Earshoots, 1958 (One Plant per 40" x 40" Hill)

	Hybrid and earshoots removed													
	Hy2 x Oh7			WF9 x M14			WF9 x Hy2			Hy2 x Oh41			WF9 x C103	
	Check (none)	First	First and second	Check (none)	First	First and second	Check (none)	First	First and second	Check (none)	First	First and second	Check (none)	First and second
Number of plants	4	1	3	5	4	5	4	1	3	4	1	4	10	2
Number of plants with silks on														
First earshoots	4	0	0	5	0	0	4	0	0	4	0	0	10	0
Second earshoots	4	1	0	5	4	0	4	1	0	3	1	0	10	0
Third earshoots	2	1	3	0	4	5	1	1	3	0	1	4	0	2
Fourth earshoots	0	1	3	0	0	5	0	0	3	0	0	4	0	2
Fifth earshoots	0	0	1	0	0	5	0	0	3	0	0	1	0	0
Sixth earshoots	0	0	0	0	0	5	0	0	2	0	0	0	0	0
Average silking date of														
First earshoots	7/29	...	...	7/24	...	...	7/26	...	...	7/28	...	...	7/27	...
Second earshoots	7/30	7/28	...	7/25	7/25	...	7/27	7/27	...	7/29	7/28	...	7/27	...
Third earshoots	7/31	7/29	7/29	...	7/26	7/25	8/4	7/28	7/28	...	7/30	7/29	...	7/30
Fourth earshoots	...	8/9	8/1	...	...	7/26	...	...	7/31	...	...	8/8	...	8/1
Fifth earshoots	...	...	8/11	...	...	7/27	...	...	8/4	...	...	8/15	...	...
Sixth earshoots	...	...	...	...	...	7/29	...	...	8/7	...	...	...	...	...
Number of plants with														
First ears	4	0	0	5	0	0	4	0	0	4	0	0	10	0
Second ears	4	1	0	3	4	0	1	1	0	3	1	0	0	0
Third ears	0	1	3	0	1	5	0	0	3	0	0	4	0	2
Fourth ears	0	0	3	0	0	2	0	0	2	0	0	2	0	1
Fifth ears	0	0	1	0	0	0	0	0	2	0	0	1	0	0
Sixth ears	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Average weight of dry grain (gm.)														
First ears	238	...	...	239	...	...	280	...	...	220	...	...	325	...
Second ears	178	249	...	70	274	...	13	297	...	156	214	...	...	...
Third ears	...	136	211	...	4	228	...	...	252	...	...	219	...	275
Fourth ears	...	...	153	...	...	48	...	...	39	...	...	9	...	4
Fifth ears	...	...	15	...	...	...	...	...	28	...	...	7	...	...
Sixth ears	...	...	...	...	...	51	...	...	...	...	...	...	...	...
Average weight per 100 dry kernels (gm.)														
First ears	31.8	...	...	29.2	...	...	33.3	...	...	33.6	...	...	41.4	...
Second ears	28.7	34.2	...	27.8	32.6	...	14.0	32.4	...	30.9	31.8	...	...	...
Third ears	...	26.4	32.0	...	15.9	28.0	...	...	32.5	...	...	34.1	...	41.2
Fourth ears	...	...	30.9	....	...	25.2	...	...	33.7	...	...	26.1	...	14.6
Fifth ears	...	...	22.5	...	...	...	...	...	24.6	...	...	26.2	...	...
Sixth ears	...	...	...	...	...	21.4	...	...	...	...	...	...	...	...
Average weight per dry cob (gm.)														
First ears	43.0	...	...	46.6	...	...	59.3	...	...	49.1	...	...	73.6	...
Second ears	30.9	43.6	...	14.0	61.1	...	3.2	69.8	...	28.7	41.6	...	...	...
Third ears	...	17.6	38.7	...	.8	46.2	...	...	52.4	...	...	54.1	...	57.2
Fourth ears	...	...	24.0	...	...	9.0	...	...	9.6	...	...	4.6	...	3.3
Fifth ears	...	...	3.6	...	...	...	...	...	5.5	...	...	2.3	...	...
Sixth ears	...	...	...	...	...	8.0	...	...	...	...	...	...	...	...
Average length per dry cob (cm.)														
First ears	21.7	...	...	21.0	...	...	22.1	...	...	22.2	...	...	26.4	...
Second ears	17.6	22.8	...	17.7	22.9	...	10.9	23.0	...	19.1	20.8	...	...	...
Third ears	...	14.3	20.2	...	6.4	20.8	...	...	19.1	...	...	21.7	...	22.2
Fourth ears	...	...	15.5	...	...	15.5	...	...	10.7	...	...	11.4	...	6.2
Fifth ears	...	...	9.2	...	...	...	...	...	7.8	...	...	10.2	...	...
Sixth ears	...	...	...	...	...	11.7	...	...	...	...	...	...	...	...
Average diameter per dry cob (cm.)														
First ears	2.7	...	...	3.1	...	...	3.0	...	...	2.9	...	...	3.0	...
Second ears	2.6	2.7	...	2.6	3.0	...	2.4	3.1	...	2.9	2.9	...	...	...
Third ears	...	2.1	2.6	...	1.9	2.8	...	...	2.9	...	...	3.0	...	2.9
Fourth ears	...	...	2.4	...	...	2.8	...	...	2.3	...	...	2.0	...	2.1
Fifth ears	...	...	1.5	...	...	...	...	...	2.1	...	...	2.2	...	...
Sixth ears	...	...	...	...	...	2.6	...	...	...	...	...	...	...	...

EARSHOOT COVERAGE VERSUS EARSHOOT REMOVAL

Covering the first (functional) earshoot of the two-ear hybrid L317 x R4 before silking increased the grain yield of the second (functional) earshoot from 145 grams (on the check plants) to 264 grams but had no stimulatory effect on grain production by the third (nonfunctional) earshoot (Table 5). Removing the first (functional) earshoot of the hybrid before silking increased the grain yield of the second (functional) earshoot from 145 to 210 grams and stimulated the production of 136 grams of grain by the third (nonfunctional) earshoot (Table 7).

Covering the second (functional) earshoot before silking increased the yield of grain of the first (functional) earshoot from 186 grams (on the check plants) to 262 grams but did not stimulate grain production by the third (nonfunctional) earshoot. Removing the second (functional) earshoot before silking increased the grain yield of the first (functional) earshoot from 186 to 250 grams and stimulated the production of 44 grams of grain by the third (nonfunctional) earshoot and 13 grams of grain by the fourth (nonfunctional) earshoot.

Covering one of the two functional earshoots before silking, therefore, stimulated a greater increase in grain yield from the other functional earshoot than did removing either of the functional earshoots. However, nonfunctional earshoots were stimulated to produce grain much more when the functional earshoots were removed than when the functional earshoots were covered. Neither covering nor removing nonfunctional earshoots before silking of the functional earshoots had any stimulating effect on the grain production of the functional earshoots (Tables 5, 7, and 9). Both the earshoot-covering and the earshoot-removal experiments demonstrate the strong dominance effect of functional earshoots over the development of nonfunctional earshoots.

EFFECTS OF DATE OF REMOVAL OF THE FIRST EARSHOOT

Since removing the first (functional) earshoot of the two-ear hybrid L317 x R4 before silking resulted in the development of the third (nonfunctional) earshoot, the question arose as to what effect the age of the first (functional) earshoot at the time of removal would have on grain production of the third (nonfunctional) ear-

Table 9. Effects on Grain Production of Earshoots of WF9 x M14 When Certain Earshoots Were Removed Before Silking of the First Earshoots, 1960 (One Plant per 40" x 12" Hill)

	Earshoots Removed						
	Check (none)	Third	Second	Second and third	First	First and second	First, second, and third
Number of plants	10	10	9	9	9	9	11
Number of plants with silks on							
First earshoots	10	10	9	9	0	0	0
Second earshoots	7	4	0	0	9	0	0
Third earshoots	0	0	0	0	0	9	0
Fourth earshoots	0	0	0	0	0	0	11
Fifth earshoots	0	0	0	0	0	0	4
Average silking date of							
First earshoots	7/28	7/28	7/27	7/28	...	...	...
Second earshoots	7/30	7/29	...	...	7/28	...	...
Third earshoots	...	...	...	...	...	7/30	...
Fourth earshoots	...	...	...	...	...	...	7/31
Fifth earshoots	...	...	...	...	...	...	8/2
Number of plants with							
First ears	10	10	9	9	0	0	0
Second ears	0	0	0	0	9	0	0
Third ears	0	0	0	0	0	9	0
Fourth ears	0	0	0	0	0	0	11
Fifth ears	0	0	0	0	0	0	4
Average weight of dry grain (gm.)							
First ear	235	221	221	222	...	...	...
Second ear	...	...	...	...	229	...	...
Third ear	...	...	...	...	...	198	...
Fourth ear	...	...	...	...	...	...	138
Fifth ear	...	...	...	...	...	...	20
Sixth ear	...	...	...	...	...	...	9

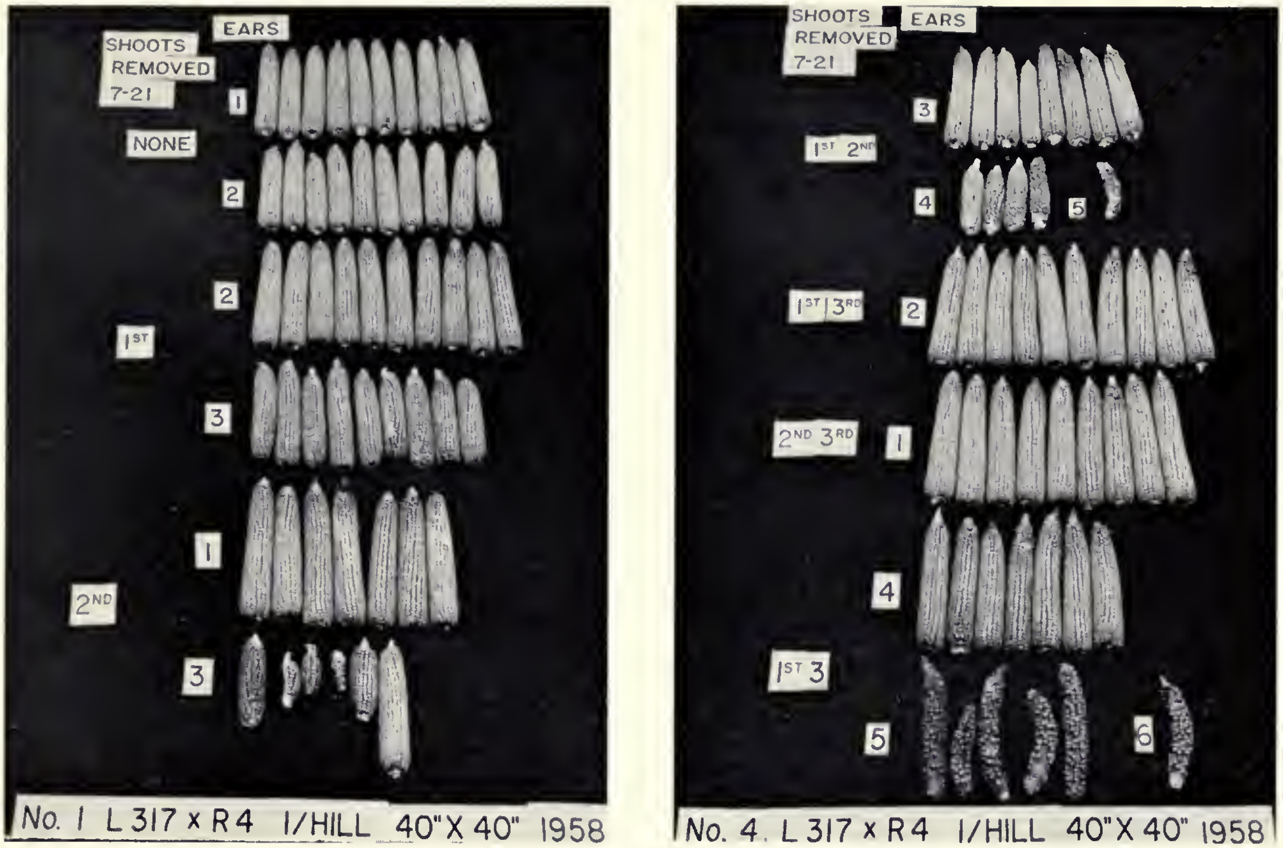

Figure 9. Effects of removing certain earshoots from L317 x R4 (a two-ear hybrid) before silking of the first earshoots.

shoot. To answer this question, L317 x R4 seeds were planted May 15, 1955, and grown at the rate of one plant per 40″ x 40″ hill (Inselberg, 1956). Tillers were removed when very small. Since none of the earshoots was covered, all silks were pollinated naturally as they emerged from the husk. First (functional) earshoots were then removed at two-day intervals beginning July 29, which was one day after the mean silking date of the first earshoots.

Although no grain weights were taken, it is clear from the data in Table 10 and from the representative ears shown in Figure 11 that the time of removal of the first (functional) earshoot had no apparent effect on ear size and seed set of the second (functional) earshoot but quite definitely affected ear size and seed set of the third (nonfunctional) earshoot. Stimulation of the third (nonfunctional) earshoots was greatest when first earshoots were removed on July 29 and least when first earshoots were removed between August 6 and August 14.

Table 11 shows the effect on grain yield of the second (functional) and third (nonfunctional) earshoots of L317 x R4 when the first (functional) earshoot was removed at different stages of development. Seeds were planted June 1, 1957, and grown at one plant per 40″ x 40″ hill. Earshoots of the check plants were left uncovered. The first, second, and third earshoots of the test plants, however, were covered before silking and kept covered until the first earshoot was removed, at which time the second and third earshoots were uncovered, their silks clipped, and the earshoots pollinated.

Grain yield of second (functional) earshoots was stimulated when first earshoots were removed from August 2 to August 10. By August 12, however, 10 days after the average silking date of the second earshoots, grain production by the second earshoots was about one-fourth that of the second earshoots of the check plants. Either the silks had deteriorated to the point where pollination resulted in the production of only a few kernels per ear (Peterson, 1942), or the pollen used was of poor quality, or most of the functional ovules had become nonfunctional. (It should be noted that covering functional earshoots before silking and preventing them from being pollinated does not prevent normal development of cobs, silks, and functional ovules.)

Third (nonfunctional) earshoots received maximum stimulation when first (functional) earshoots were removed on August 2, five days before the average silking date of the third earshoots and one day after the average silking date of the first earshoots. Removing the first (functional) earshoots during the period from August 8 to August 14 stimulated little development of the third (nonfunctional) earshoots. The lower grain yields of the second and third ears in this experiment probably resulted from the late planting.

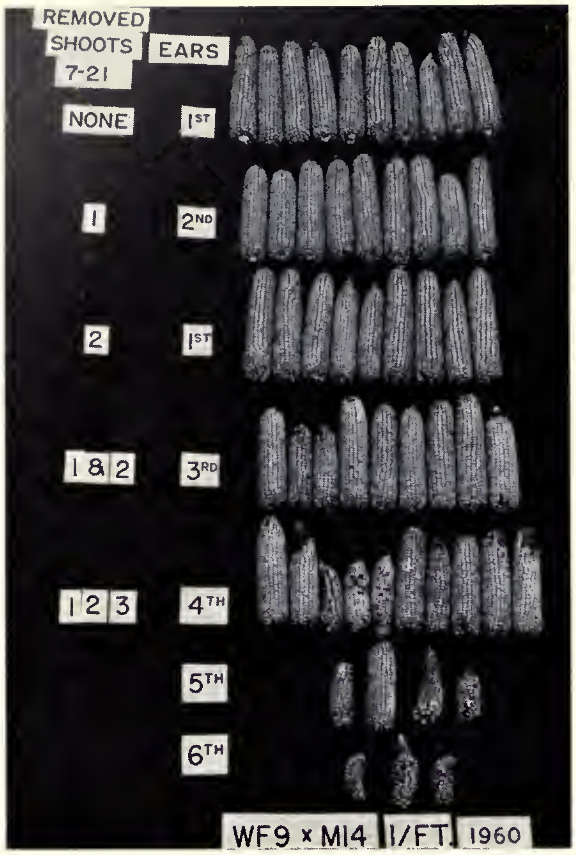

Figure 10. Effects of removing certain earshoots from WF9 x M14 (a one-ear hybrid, grown at one plant per 40" x 12" hill) before silking of the first earshoots.

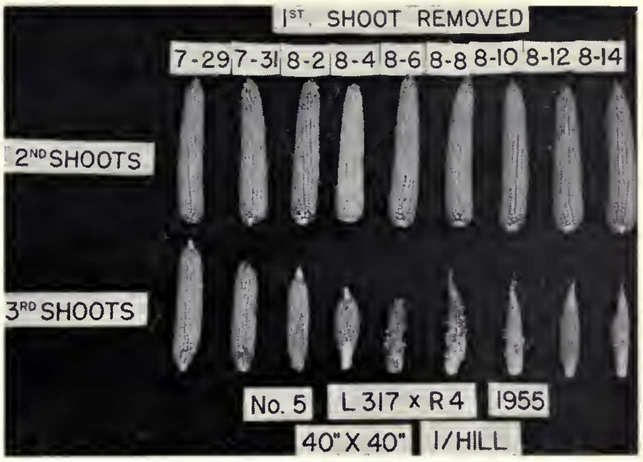

Figure 11. Effects on the yield of grain by the second (functional) and third (nonfunctional) earshoots when the first (functional) earshoots were removed at different stages of development. All earshoots were left uncovered and pollinated naturally.

At greater rates of planting

When L317 x R4 is grown at three plants per 40" x 40" hill, usually only the first earshoot is functional. The effects on second (nonfunctional) earshoots when first (functional) earshoots are removed at different stages of development are presented in Table 12 and Figure 12. The earshoots of the check plants were left uncovered, and the first and second earshoots of the other plants were covered before silking. When the first earshoots were removed from certain plants, the second earshoots of these plants were uncovered and pollinated. Stimulation of the second (nonfunctional) earshoot to produce grain was greatest at the first date of removal, decreasing with successive dates of removal.

When the first (functional) earshoots were removed during the period from August 4 to August 12, the lower part of the cobs of some second ears failed to produce grain (Fig. 12), apparently because of poor cob and silk development (Fig. 13). Some second cobs produced no grain on their lower portions, even though apparently fully developed there, whereas others were definitely underdeveloped. In most cases the upper parts of the

Table 10. Effects of Date of Removal of First Earshoots of L317 x R4 on Grain Production of the Third Ears, 1955 (One Plant per 40" x 40" Hill)

	Date of removal of first earshoots									
	Check	7/29	7/31	8/2	8/4	8/6	8/8	8/10	8/12	8/14
Number of plants	104	43	38	80	40	37	39	39	35	36
Silking date of										
First earshoots.	7/29	7/28	7/28	7/29	7/28	7/29	7/29	7/28	7/29	7/29
Second earshoots	7/29	7/30	7/29	7/30	7/29	7/29	7/30	7/29	7/30	7/29
Third earshoots.	7/31	8/1	7/31	8/1	8/1	7/31	7/31	7/30	7/31	7/31
Number of plants with silks on third earshoots[a].	86	43	37	72	37	32	35	30	30	29
Number of plants with grain on third ears.	1	43	34	47	16	6	4	2	5	3
Third-ear equivalent[b].	0	79	64	34	12	2	2	1	6	3

[a] All second earshoots produced full-sized ears.

[b] Third-ear equivalent is the product of the percent the length of the third ear is of the length of the first ear of the check plants at maturity multiplied by the percent seed set of the third ear and divided by 100.

cobs were fully developed. Some of the cobs displayed a sharp division between the lower undeveloped and the upper developed parts.

The growth-promoting substances and other factors that caused the upper part of the second (nonfunctional) earshoots to develop upon removal of the first (functional) earshoots must have had little effect on the development of the lower part of some of the cobs and their silks, although such factors may have passed through the lower part of these cobs in reaching the upper part. Apparently, the growth activity of the cells on the lower part of these second (nonfunctional) earshoots had become too low by August 4 to be accelerated by an increase in growth-promoting substances. The cells on the upper part of these second (nonfunctional) earshoots had obviously not yet reached the stage of senescence or inactivation.

Although the check plants developed no second ears at this rate of planting, the appearance of a few fully developed second ears at the later dates of first earshoot re-

Table 11. Effects of Date of Removal of First Earshoots of L317 x R4 on Grain Production of the Lower Earshoots, 1957 (One Plant per 40" x 40" Hill)

		Date of removal of first earshoots						
	Check	8/2	8/4	8/6	8/8	8/10	8/12	8/14
Number of plants	9	6	6	6	6	5	5	6
Average silking date of								
First earshoots	8/3	8/1	8/1	8/2	8/2	8/1	8/1	8/2
Second earshoots	8/4	8/5	8/2	8/3	8/3	8/2	8/2	8/3
Third earshoots	8/6	8/7	8/5	8/8	8/10	8/6	8/5	8/10
Number of plants with silks on								
First earshoots	9	3[a]	6	6	6	5	5	6
Second earshoots	9	6	6	6	6	5	5	6
Third earshoots	4	6	6	6	4	3	5	5
Number of plants with grain on								
First ears	9	...	...	...	...	...	...	...
Second ears	9	6	6	6	6	5	5	5
Third ears	0	6	4	5	2	1	0	1
Average weight of dry grain (gm.)								
First ears	173	...	...	...	...	...	...	...
Second ears	120	152	175	168	189	136	29	4
Third ears	...	88	45	43	17	5	...	1
Average weight per dry cob (gm.)								
First ears	37.3	...	...	...	...	...	...	...
Second ears	25.6	38.2	37.7	38.7	42.7	40.6	29.8	21.5
Third ears	...	23.3	9.1	12.6	6.9	1.3	.4	1.1

[a] First earshoots on other three plants had not silked by date of removal.

Table 12. Effects of Date of Removal of First Earshoots of L317 x R4 on Grain Production of Second Ears, 1957 (Three Plants per 40" x 40" Hill)

		Date of removal of first earshoots						
	Check	8/2	8/4	8/6	8/8	8/10	8/12	8/14
Number of plants	10	7	8	8	8	7	8	11
Average silking date of								
First earshoots	8/2	8/1	8/2	8/1	8/1	8/2	8/1	8/1
Second earshoots	8/3	8/5	8/9	8/14	8/7	8/11	8/10	8/5
Number of plants with silks on								
First earshoots	10	5[a]	8	8	8	7	8	11
Second earshoots	4	7	7	7	7	6	6	6
Number of plants with grain on								
First ears	10	...	...	...	...	...	...	...
Second ears	0	7	6	7	3	4	0	0
Average weight of dry grain (gm.)								
First ears	199	...	...	...	...	...	...	...
Second ears	...	161	95	53	62	33	...	...
Average weight per dry cob (gm.)								
First ears	38.4	...	...	...	...	...	...	...
Second ears	.4	34.5	26.4	22.1	12.9	12.7	.6	.5

[a] First earshoots had not silked on two plants by date of removal.

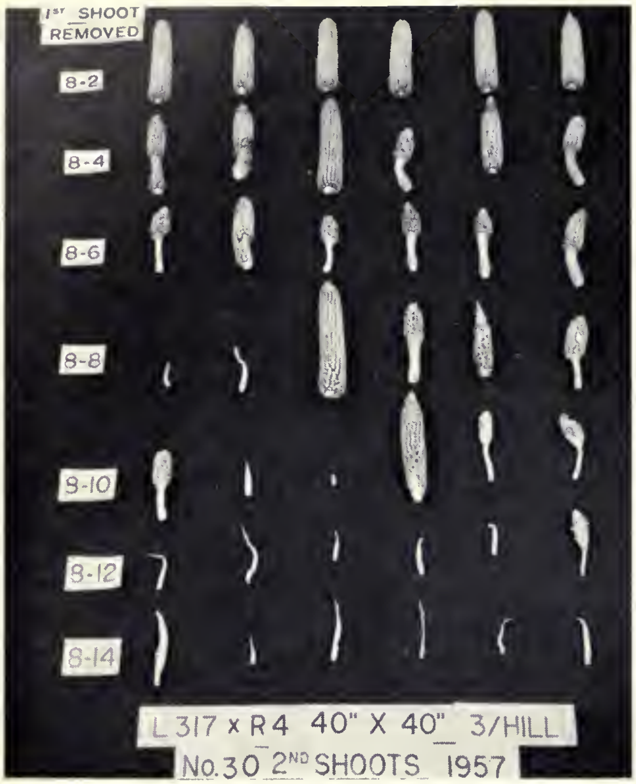

Figure 12. Effects of removing the first (functional) earshoots from L317 x R4, grown at three plants per 40" x 40" hill. All earshoots were covered before silking. When the first earshoots were removed, the second (nonfunctional) earshoots were uncovered and pollinated by hand.

moval indicates that small or medium-sized ears may well have developed from the second earshoots on those plants even if the first earshoots had not been removed.

On various hybrids

Figure 14 shows the results of stimulating grain production on the second (nonfunctional) earshoots of one-ear hybrids (WF9 x M14, Hy2 x Oh41, WF9 x Hy2, WF9 x C103) by removing the first (functional) earshoots three, five, and seven days after silking. Seeds were planted May 15, 1958, and grown at one plant per 40" x 12" hill. The first and second earshoots were covered on all plants except checks before silking. When the first (functional) earshoots were removed, the second (nonfunctional) earshoots were uncovered and allowed to pollinate naturally. The weight of grain was not recorded.

The earliest removal of the first (functional) earshoots from these one-ear hybrids (three days after silking) stimulated fairly good cob and grain production by the second (nonfunctional) earshoots. Removal of the first (functional) earshoots five and seven days after silking produced variable results, although smaller cobs and much less grain were produced.

The development of the third (nonfunctional) earshoot of a two-ear hybrid (L317 x R4) was studied in terms of the relationship between the date of removing the first (functional) earshoot, the date of silking of the first earshoot, and the date of silking of the third earshoot (Fig. 15). The seeds were planted May 15, 1955, and grown at one plant per 40" x 40" hill. The third (nonfunctional) earshoots had maximum growth and seed set when the first (functional) earshoots were removed one to three days before silking (based on silking dates of first earshoots of the check plants) and one to two days before the third (nonfunctional) earshoots silked. The shorter the time interval between silking of the first and third earshoot, the greater the grain production by the third earshoot when the first earshoot is removed.

Conclusions

These data show that the age or stage of development of earshoots is a most important factor in the growth of nonfunctional earshoots after functional earshoots have been removed. Removing the first (functional) earshoot of one-ear hybrids one to two days before silking gives the greatest stimulation to the second (nonfunctional) earshoot; removal about seven days after silking, however, causes very little growth and grain production by the second (nonfunctional) earshoot.

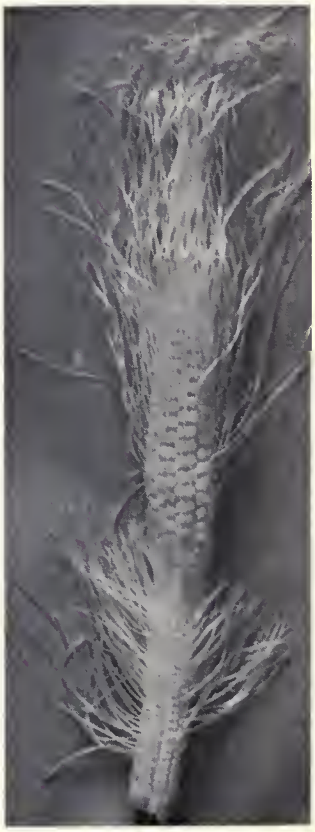

Figure 13. Typical differential development of cobs and silks of second (nonfunctional) earshoots of L317 x R4, grown at three plants per 40" x 40" hill. First (functional) earshoots were removed August 7 and second earshoots harvested August 12, 1957. First and second earshoots were covered before silking and second earshoots were kept covered until harvested.

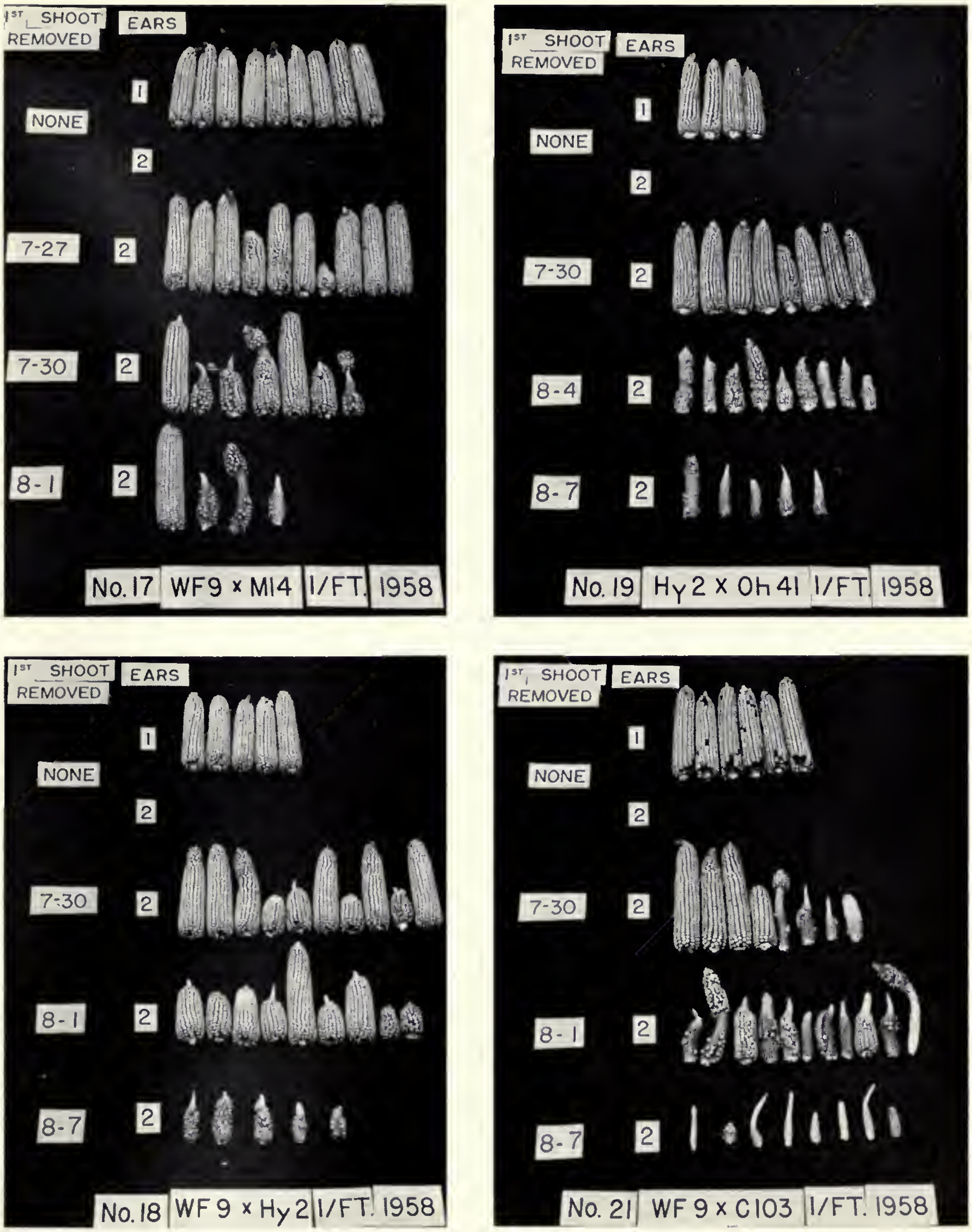

Figure 14. Effects on second (nonfunctional) earshoots of one-ear hybrids, grown at one plant per 40" x 12" hill, when first (functional) earshoots were removed 3, 5, and 7 days after silking. Earshoots were covered before silking. When the first earshoots were removed, the second earshoots were uncovered and pollinated naturally.

NUMBER OF DAYS BEFORE OR AFTER THIRD EARSHOOTS SILKED THAT FIRST EARSHOOTS WERE REMOVED

NUMBER OF DAYS AFTER THEY SILKED THAT FIRST EARSHOOTS WERE REMOVED	BEFORE													AFTER						
	12	11	10	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
*						66	69	62	83	85	95	95								
0						–	–	63	–	83	86	–								
1	1	–	–	36	21	–	–	–	–	83	85	88								
2						31	–	45	54	–	77	77	72	72	88					
3						2	–	–	37	18	–	63	66	72	81	85				
4						0	–	–	12	–	–	0	56	51	74	24	64			
5									–	–		0	–	33	15	19	45			
6									0	–	–	–	0	–	0	17	9	38		
7																0	11	16	0	
8																	0	2	1	7

* First earshoots were removed 1 to 3 days before they would have silked, based on silking dates of the first earshoots of check plants.

Figure 15. Grain production of third (nonfunctional) earshoots of L317 x R4 (two-ear hybrid, grown at one plant per 40″ x 40″ hill) as related to date of removal of the first (functional) earshoot, date of silking of the first earshoot, and date of silking of the third earshoot. The numbers in each square represent the "third-ear equivalent": the percent the length of the third ear is of the length of the first ears of the check plants at maturity, multiplied by the percent seed set of the third ear, and divided by 100.

It is unclear why a few days' difference in stage of earshoot development (as measured by date of silking) at the time of removal of functional earshoots is so important in affecting growth and yield of grain of the upper nonfunctional earshoots. It is known, however, that the quantity of growth-promoting substances produced by leaves, shoot tips, and axillary buds is directly related to their age and meristematic activity (Thimann and Skoog, 1934; Avery *et al.,* 1937a; Gustafson, 1946). Apparently, the meristematic cells of cobs and ovules of nonfunctional earshoots rapidly lose their capacity to grow after the silking of the functional earshoots.

SHADED PLANTS

Covering functional earshoots and removing functional earshoots are not the only ways to stimulate nonfunctional earshoots. Shading corn plants 90 percent for six days around silking time (the period from July 19 to August 5) also stimulates some of the upper nonfunctional earshoots to develop into ears while reducing development of the functional earshoots (Fig. 16). This corn was planted May 18, 1960, and grown at one plant of each of the two hybrids per hill with 100 square feet of land per hill. The plants were shaded as described by Earley *et al.* (1966). The average silking dates of the first and second (functional) earshoots of Hy2 x Oh41 check plants were July 29 and July 31, respectively; the average silking date of the first (functional) earshoots of WF9 x C103 check plants was July 29.

The undeveloped ears appear to resemble the undeveloped ears of the one-ear hybrids in Figure 14 but not the undeveloped ears of the one-ear hybrid in Figure 12.

When Hy2 x Oh41 plants were shaded from August 6 through August 11 (after silking), the second (functional) earshoots failed to develop. Although the results of this short period of intensive shading resemble those of a longer period of shading of the same hybrid (Fig. 17), the causes are probably not simliar. The effects of longer shading in preventing the development of the second (functional) earshoots do, however, resemble the effects of higher rate of planting of Hy2 x Oh7 (Fig. 6) and probably result from similar causes.

For example, shading Hy2 x Oh41 plants 90 percent from July 19 through July 24, or from July 25 through July 30, delayed silking of the second (functional) ear-

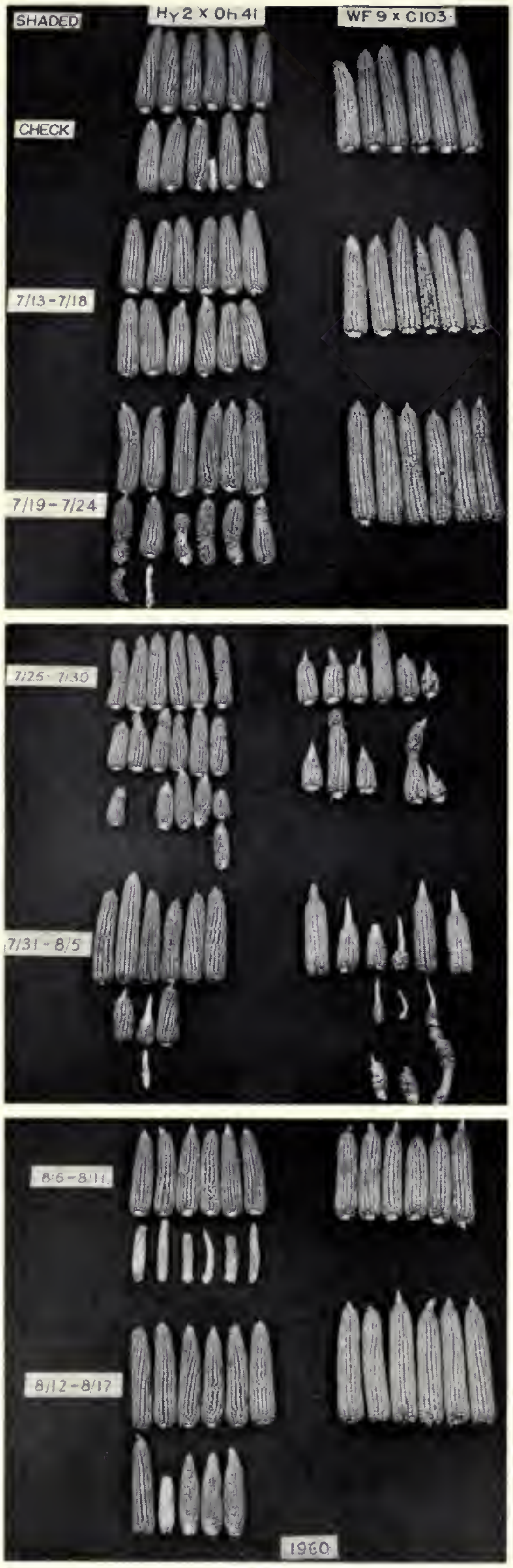

Figure 16. Effects on number and size of ears per plant when shaded 90 percent for six days only.

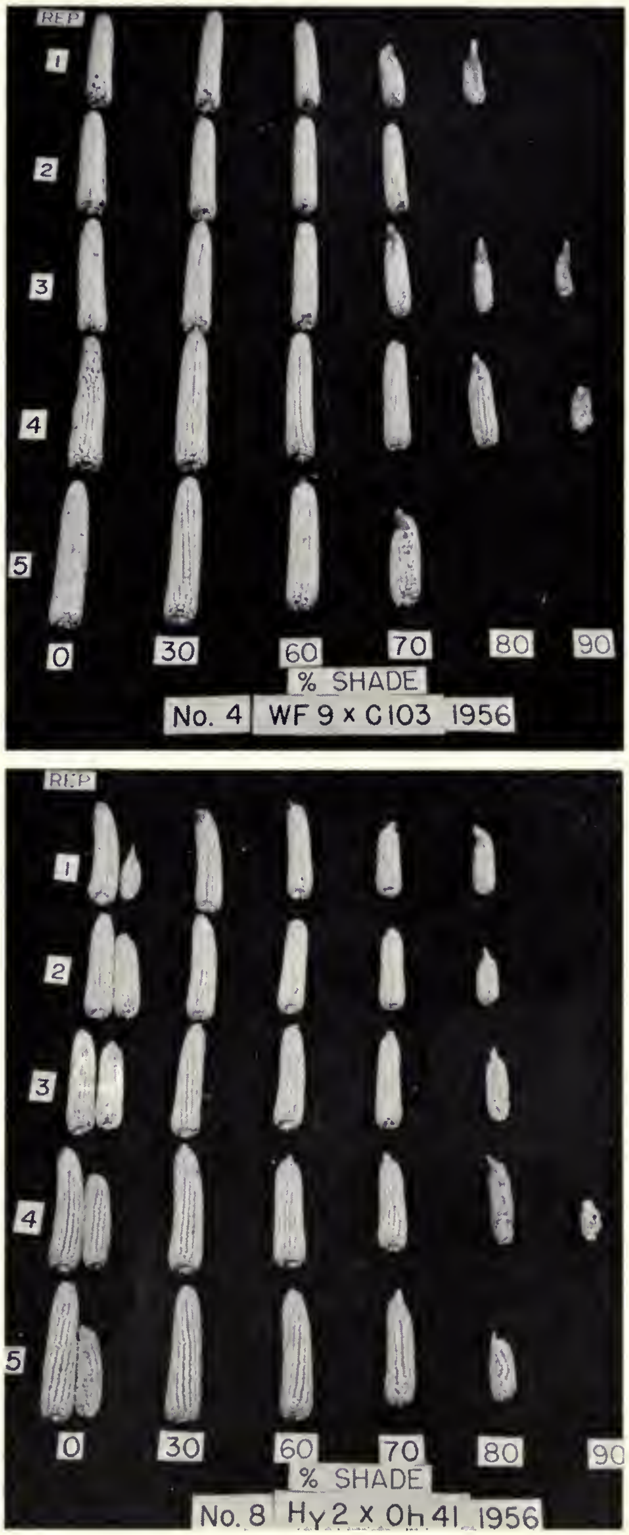

Figure 17. Effects on number and size of ears per plant when plants are shaded at various percentages from June 8 through September 28. Seeds were planted May 8 and grown at one plant of each hybrid per hill with 265 square feet of land per hill. Each plant produced a top earshoot that silked and was hand-pollinated. Five replications are presented for each shade condition.

shoots four and five days, respectively, after the silking of the first (functional) earshoots but did not cause the second (functional) earshoots to be nonfunctional. Delaying the silking of second earshoots of two-ear hybrids for four or five days after the silking of the first (functional) earshoots by increasing the rate of planting (Fig. 6) or by continuous shading (Fig. 17), however, did result in nonfunctional second earshoots.

LENGTH OF TIME BETWEEN SILKING OF EARSHOOTS

Because simultaneous pollination of all silking earshoots on several single-cross hybrids did not produce any more ears than did natural pollination (Table 4), it was decided to study the effect of the length of time between silking of the first and the lower earshoots on the grain production of the lower ones.

Data from several experiments (presented in Tables 13, 14, and 15) show that all lower earshoots that silk usually do so within three or four days of the first earshoot and, further, that most of the lower functional earshoots and some of the upper nonfunctional earshoots silk within two days of the first (functional) earshoot. The interval between silking of the first and lower earshoots, therefore, is not an accurate criterion for predicting the number of functional and nonfunctional earshoots per plant; rather, the relative size of earshoots at silking is a better indicator of their functional ability.

Silk production by ovules is somewhat independent of earshoot size and of the functional ability of the ovules, as shown by simultaneous pollination of all silking earshoots on a plant. Consequently, proximity of silking of two or more earshoots per plant is only one prerequisite for multiple-ear production.

LENGTH OF TIME BETWEEN POLLINATION OF EARSHOOTS

To determine the effect of length of time between pollination of the first and second (functional) earshoots on the grain production of each earshoot, L317 x R4 seed was planted May 18, 1961, and grown at one plant per 40" x 24" hill. First, second, and third earshoots were covered before silking, and the third (nonfunctional) earshoots were kept covered throughout the experiment. The first and second earshoots had silked by July 31, after which the following pollination treatments were used:

1. First and second earshoots were pollinated simultaneously — one group on August 1, one group on August 4, and a third group on August 7.
2. All first earshoots were pollinated on August 1; some second earshoots were pollinated on August 4, the other second earshoots on August 7.
3. All second earshoots were pollinated on August 1; some first earshoots were pollinated on August 4, the others on August 7.

Table 13. Effects of the Number of Days Between Silking of First and Second Earshoots of WF9 x M14 on Grain Production of Second Ears[a]

Days between silking of first and second earshoots	Number of plants: Per category	Number of plants: With grain on second ears
	40" x 12" hills, 1958	
0	9	1
1	7	0
2	2	0
3	1	0
	40" x 12" hills, 1960	
0	4	0
1	10	0
2	8	0
3	1	0
> 3[b].	18	0
	40" x 12" hills, 1961	
0	1	0
1	1	0
2	0	0
3	1	0
4	1	0
> 4[b].	18	0
	40" x 13-1/3" hills, 1964	
0	1	0
1	28	0
2	18	0
3	3	0

[a] Second earshoots on check plants were nonfunctional at this planting rate.

[b] Earshoots did not silk.

The resulting data (Table 16) show that delaying simultaneous pollination of the two functional earshoots caused a decrease in grain yield of the first ear and an increase in grain yield of the second ear. Grain production of the two functional earshoots was not greatly impaired by pollinating either earshoot three or six days later than the other, although the earshoot that was pollinated earlier produced more grain than the other earshoot.

Thus, the failure of lower earshoots with silks to grow and produce grain is due to causes other than being pollinated a few days later than the upper functional earshoot. In this connection, Sass (1960) concluded, "The failure of complete development of the second ear (of a one-ear hybrid) is not ascribed to inadequate ovule development by the time of anthesis, nor to failure of pollination of this ear, but to factors associated with competition prior to and after anthesis." Therefore, for specific reasons unknown, earshoots that do not grow beyond the silk stage may have all or some of their ovules fertilized but produce little or no grain.

Compensatory growth of earshoots. The data on reciprocal pollination of functional earshoots (Table 16) and the data on earshoot coverage and removal (Tables 5 through 9) show a reciprocal compensatory relationship for grain yield among functional earshoots but only

Table 14. Effects of Number of Days Between Silking of First and Lower Earshoots of L317 x R4 on Grain Production of the Lower Ears

Days between silking of first earshoots and silking of	Number of plants Per category	 With grain on lower ears
80" x 80" hills, 1955		
Second earshoots		
0	19	19
1	57	57
2	3	3
Third earshoots		
0	2	2
1	20	19
2	44	38
3	13	7
40 " x 40" hills, 1955		
Second earshoots		
0	37	37
1	62	62
2	5	5
Third earshoots[a]		
0	2	0
1	12	1
2	37	0
3	27	0
4	8	0
>4[b]	18	0
40" x 40" hills, 1956		
Second earshoots		
0	8	8
1	28	28
2	9	9
Third earshoots[a]		
0	0	0
1	1	0
2	8	1
3	8	1
4	3	0
>4[b]	25	0
40" x 36" hills, 1958		
Second earshoots		
0	12	12
1	13	13
2	1	1
Third earshoots[a]		
0	0	0
1	1	0
2	2	0
3	4	0
4	2	0
>4[b]	17	0
40" x 24" hills, 1961		
Second earshoots		
0	3	3
1	14	14
Third earshoots[b]		
40" x 13-1/3" hills, 1955		
Second earshoots		
0	4	2
1	26	4
2	18	2
3	4	0
Third earshoots[b]		
40" x 13-1/3" hills, 1957		
Second earshoots[a]		
0	1	0
1	1	0
2	1	0
3	0	0
4	1	0
>4[b]	6	0
Third earshoots[b]		

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[a] Nonfunctional at this rate of planting.
[b] Earshoots did not silk.

Table 15. Effects of Number of Days Between Silking of First and Lower Earshoots of Various Hybrids on Grain Production of the Lower Ears

Days between silking of first earshoot and silking of	Number of plants Per category	 With grain on lower ears
2110 x 540--40" x 40" hills, 1950		
Second earshoots		
0	4	4
1	4	4
2	2	2
Third earshoots		
1	3	2
2	3	2
3	4	2
Fourth earshoots[a]		
2	9	0
3	9	0
4	9	0
5	9	0
6	9	0
2110 x K64--40" x 40" hills, 1950		
Second earshoots		
0	3	3
1	6	6
2	1	1
Third earshoots[a]		
2	1	0
3	5	1
4	2	0
5	2	0
>5[b]	1	0
W8 x L317--40" x 40" hills, 1950		
Second earshoots		
0	1	1
1	5	5
2	4	4
Third earshoots[a]		
2	6	0
3	6	0
4	6	0
>4[b]	4	0
L317 x 540--40" x 40" hills, 1950		
Second earshoots		
0	5	5
1	3	3
2	2	2
Third earshoots[a]		
1	1	0
3	5	0
>3[b]	4	0
Hy2 x Oh7--40" x 24" hills, 1960		
Second earshoots		
0	6	6
1	17	17
2	2	2
>2[b]	1	0
Hy2 x Oh7--40" x 13-1/3" hills, 1964		
Second earshoots[a]		
1	3	0
2	5	0
3	3	0
>3[b]	39	0
Hy2 x Oh41--40" x 12" hills, 1961		
Second earshoots[a]		
1	1	0
2	4	0
>2[b]	17	0
WF9 x C103--40" x 13-1/3" hills, 1964		
Second earshoots[a]		
1	1	0
2	2	0
3	1	0
4	1	0
>4[b]	50	0

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[a] Nonfunctional at this rate of planting.
[b] Earshoots did not silk.

Table 16. Effects of Length of Time Between Pollination of the Two Functional Earshoots of L317 x R4 on Yield of Grain, 1961 (14 Plants per Treatment, One Plant per 40″ x 24″ Hill)

Date of pollination First earshoot	Date of pollination Second earshoot	Aver. weight of dry grain per ear (gm.) First ear	Aver. weight of dry grain per ear (gm.) Second ear	Total weight of dry grain for first and second ears (gm.)
8/1	8/1	199	150	349
8/4	8/4	162	146	308
8/7	8/7	157	165	322
8/1	8/4	182	139	321
8/1	8/7	210	124	334
8/4	8/1	162	177	339
8/7	8/1	133	197	330

a basipetal compensatory relationship between functional and nonfunctional earshoots. Apparently, however, neither of these compensatory relationships comes into play unless one or more of the functional earshoots fail to develop normally. Compensatory growth in other plants has been discussed by Jacobs and Bullwinkel (1953).

CONVERSION OF NONFUNCTIONAL EARSHOOTS INTO FUNCTIONAL EARSHOOTS

Seeds of WF9 x M14 were planted May 24, 1960, and grown at one plant per 40″ x 12″ hill; first and second earshoots were covered before silking. After both earshoots had silked, the first (functional) earshoots were removed on July 29 and the second (nonfunctional) earshoots were pollinated once only then covered on different lots of plants on July 29, July 30, July 31, and August 1.

The second (nonfunctional) earshoots became functional shortly after removal of the first (functional) earshoots (Table 17). Second-ear grain yields increased steadily from 152 grams for the plants pollinated July 29 to 218 grams for the plants pollinated August 1. Second (nonfunctional) earshoots of the check plants produced no grain. Obviously, removing the first (functional) earshoots on July 29 brought about changes in most of the ovules of the second (nonfunctional) earshoots quickly enough to develop the newly formed zygotes into mature kernels of corn. The lower grain yield from the second ears that were pollinated earlier (July 29) could have been the result of either the availability of fewer silks for pollination or the time-lag in the conversion of nonfunctional ovules into functional ovules from the base of the second earshoot to its tip after the first (functional) earshoot had been removed (Levings, 1956).

Growth rates are studied in another respect on pages 30-31, where growth rates of the first (functional) earshoots and the third (nonfunctional) earshoots of the two-ear hybrid L317 x R4, with and without removal of the first earshoots at silking, are discussed.

CHEMICAL COMPOSITION OF EARSHOOTS

Concentration of indoleacetic acid (IAA)

Hybrid 2110 x 540 was planted May 16, 1951, and grown at one plant per 40″ x 40″ hill (Lyons, 1952). Each plant produced four to six earshoots with silks and would normally have produced three ears after pollination. To prevent pollination, however, all earshoots were covered with glassene bags before silking and treated in four groups as follows:

1. Unpollinated earshoots were harvested at silking.
2. Unpollinated earshoots were harvested 10 days after silking.
3. All silking earshoots on a plant were pollinated simultaneously at silking and harvested 10 days later.
4. The first and second (functional) earshoots were removed at silking; the lower earshoots with silks were pollinated simultaneously and harvested 10 days later.

Each harvested earshoot was husked, labeled, frozen in dry ice in the field, and stored at −23° C until lyophilized. After drying, the earshoots were weighed, ground to pass through a 20-mesh sieve, placed in glass screwcap bottles, and stored in the dark until analyzed. The amounts of IAA in these earshoots were determined by the colorimetric procedure of Tang and Bonner (1947)

Table 17. Rate of Conversion of Second (Nonfunctional) Earshoots of WF9 x M14 Into Functional Earshoots Upon Removal of First (Functional) Earshoots, 1960 (One Plant per 40″ x 12″ Hill)

Number of plants	Av. silking date First earshoot	Av. silking date Second earshoot	Date first earshoots removed	Date second earshoots pollinated	Av. grams dry grain per ear First ear	Av. grams dry grain per ear Second ear
10	7/28	7/30	Check	Check	235	0
9	7/27	7/28	7/29	7/29	...	152
9	7/27	7/28	7/29	7/30	...	208
8	7/27	7/28	7/29	7/31	...	216
5	7/28	7/28	7/29	8/1	...	218

Table 18. Dry Weights and Indoleacetic Acid Equivalents of Earshoots of 2110 x 540, 1951 (One Plant per 40" x 40" Hill)

	Earshoots						
	1	2	3	4	5	6	7
Treatment 1: earshoots covered, harvested unpollinated at silking							
Dry wt./earshoot, g	5.54	5.22	2.96	0.60	0.36	...	...
IAA, mg/g dry earshoot. . . .	0.74	0.56	0.32	0.34	0.32	...	...
IAA, mg/earshoot.	4.10	2.92	0.95	0.20	0.11	...	...
Treatment 2: earshoots covered, harvested unpollinated 10 days after silking							
Dry wt./earshoot, g	10.35	10.26	7.00	0.31	0.60	...	...
IAA, mg/g dry earshoot. . . .	1.97	1.78	1.30	0.20	0.24	...	...
IAA, mg/earshoot.	20.39	18.26	9.1	0.06	0.14	...	...
Treatment 3: earshoots pollinated simultaneously at silking, harvested 10 days later							
Dry wt./earshoot, g	22.72	23.75	22.43	0.51	0.48	...	...
IAA, mg/g dry earshoot. . . .	1.82	1.89	2.08	0.24	0.18	...	...
IAA, mg/earshoot.	41.35	44.89	46.65	0.12	0.09	...	...
Treatment 4: 1st and 2nd earshoots removed at silking; the others were pollinated simultaneously, then harvested 10 days later							
Dry wt./earshoot, g	...	...	28.20	4.42	1.89	7.56	1.17
IAA, mg/g dry earshoot. . . .	...	...	2.12	1.46	1.27	1.52	0.34
IAA, mg/earshoot.	...	...	59.78	6.45	2.40	11.49	0.40

and by the bioassay method (split-pea curvature test) of Went and Thimann (1937).[1] Results of this study, designed to determine the relationship between growth and IAA concentration in the three functional earshoots and in the nonfunctional earshoots of 2110 x 540, are presented in Table 18.

The unpollinated earshoots harvested at silking (treatment 1) decreased in dry weight from the first earshoot to the lowest. The first, second, and third (functional) earshoots were several times heavier than the fourth and fifth (nonfunctional) earshoots. Unpollinated first, second, and third (functional) earshoots sampled 10 days after silking (treatment 2) doubled their dry weight during this period, but the fourth and fifth (nonfunctional) earshoots had little change in weight. The three functional earshoots pollinated at silking and harvested 10 days later (treatment 3) quadrupled their dry weight during this period, but the pollinated fourth and fifth (nonfunctional) earshoots had no appreciable increase in weight. Treatment 4 at the end of the 10-day period appreciably increased the dry weight of the third (funtional) earshoots and the dry weight and grain development of the fourth, fifth, sixth, and seventh (now functional) earshoots over the respective earshoots from treatment 3.

The concentration of IAA was considerably greater in the unpollinated first and second (functional) earshoots at silking (treatment 1) than in the third (functional) earshoots and the fourth and fifth (nonfunctional) earshoots; dry weight was a better indicator that the third earshoots were functional and the fourth and fifth earshoots were nonfunctional.

Ten days after silking, IAA concentrations in the three unpollinated functional earshoots (treatment 2) were similar to those in the pollinated functional earshoots (treatment 3) and three to four times greater than in the functional earshoots at silking (treatment 1). Concentrations of IAA in the fourth and fifth (nonfunctional) earshoots were similar in treatments 2 and 3 and slightly less than at silking (treatment 1).

Removing the first and second (functional) earshoots at silking (treatment 4) resulted in no appreciable increase in IAA concentration in the third (functional) earshoot 10 days later; IAA concentration did increase, however, in the previously normally nonfunctional fourth, fifth, sixth, and seventh (now functional) earshoots, compared with measurements from treatment 3.

Biological activity of earshoot growth-promoting substances

Water extracts of earshoots from the four treatments were assayed for growth-promoting substances (Table 19). The colorimetric method showed the presence of a growth-promoting substance in all earshoots of the four treatments and in 10-day-old kernels. The bioassay method (split-pea curvature test) showed the presence of a growth-promoting substance only in functional earshoots pollinated 10 days before harvest.

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[1] Since these two methods are not specific for IAA, the results reported as IAA refer to IAA equivalents.

Table 19. Comparison of Colorimetric and Split-Pea (Bioassay) Methods of Determining Growth-Promoting Substance Content of Earshoots of 2110 x 540, 1951

Ear-shoot number	Dry weight (gm.)	IAA (microgram/ml extract) Colorimetry	IAA (microgram/ml extract) Split-pea test
Treatment 1			
1	4.9	2.30	0
2	4.3	1.62	0
3	2.2	0.65	0
4	0.4	0.90	0
5	0.3	0.90	0
Treatment 2			
1	11.4	7.50	0
2	10.5	6.18	0
3	8.2	5.12	0
4	0.3	0.58	0
5	...	...	...
Treatment 3			
1	28.3	7.15	4
2	28.2	6.08	4
3	22.8	6.78	4
4	0.6	0.25[a]	0
5	0.5	0.25[a]	0
Treatment 4			
1	...	...	...
2	...	...	...
3	31.7	6.75	4
4	6.1	6.38	4
5	0.3	0.40[a]	0
6	7.0	5.65	4
7	1.4	1.10[a]	0

[a] No kernel growth.

On the basis of IAA standards, the split-pea curvature test indicated that the concentration of the growth-promoting substance in functional earshoots pollinated 10 days before harvest was 62 percent of that measured colorimetrically. The colorimetric method, therefore, measures at least two types of growth-promoting substances in pollinated functional earshoots.

The active growth-promoting substance in the water extract of functional, pollinated earshoots is most likely IAA from the immature kernels, based on data of Avery *et al.* (1942), Wittwer (1943), and Haagen-Smit *et al.* (1946). Both pure IAA and water extracts of unpollinated functional earshoots and of nonfunctional earshoots give a red color with the colorimetric test. But since IAA is active in the split-pea curvature test and the water extract from the nonfunctional or the functional unpollinated earshoots is not, the growth-promoting substance in the water extract of such earshoots is apparently not IAA but a precursor of IAA (Berger and Avery, 1944a and 1944b).

Consequently, it appears that cobs and kernels require different growth-promoting substances for their development. Fertilization of ovules of functional and nonfunctional earshoots apparently triggers the synthesis of the substance physiologically active in the growth of the kernels. Cobs of functional earshoots, which are growing, apparently provide the fertilized ovules with an adequate supply of a precursor to sustain kernel development, whereas cobs of nonfunctional earshoots, which are not growing, do not.

Determination of chemical composition

Another study was conducted in 1955 to determine the concentrations of minerals, sugars, and IAA in the first and second (functional) earshoots and the third (nonfunctional) earshoots of L317 x R4, as well as the dry weight of these earshoots (Inselberg, 1956). This two-ear hybrid was grown at one plant per 40" x 40" hill. None of the earshoots was covered, so all silking earshoots were pollinated naturally. First, second, and third earshoots were harvested from one set of plants, and second and third earshoots were harvested from another set of plants from which the first earshoots had been removed on July 29, the average silking date of the first (functional) earshoots of the check plants. The Munson-Walker procedure was used to determine sugars (*Official Methods,* 1955); nitrates were determined by the method of Johnson and Ulrich (1950); and IAA concentrations were determined by the procedure of Gordon and Weber (1951), as modified by Inselberg (1954). Data from this experiment are summarized in Table 20.

In the check plants at silking (July 29), the first and second (functional) earshoots were three to four times heavier than the third (nonfunctional) earshoots, which shows that the mechanism that determines the number of functional and nonfunctional earshoots per plant had been in operation for some time. The first and second (functional) earshoots rapidly increased in dry weight throughout the sampling period, July 29 to August 11, whereas the third (nonfunctional) earshoots had only slight increases; moreover, the first (functional) earshoots were significantly heavier than the second (functional) earshoots on all dates of harvest except August 8.

Removal of the first (functional) earshoots July 29 stimulated rapid development of the third (nonfunctional) earshoots into functional earshoots and had some stimulative effect on the dry weight of the second (functional) earshoots for two of the four sampling dates. Although the weight of the third (now functional) earshoots increased twelvefold from August 1 to 11, they remained significantly lighter than the second (functional) earshoots at each sampling date.

The concentration of each element measured was not significantly different in the first and second (functional)

Table 20. Dry Weights and Chemical Composition of Functional and Nonfunctional Earshoots of L317 x R4, 1955 (One Plant per 40" x 40" Hill)

Date harvested	Earshoot number (C = Check)									
	1C	2C	3C[a]	2	3[b]	1C	2C	3C[a]	2	3[b]
	Dry weight, g/earshoot					IAA, microgram/g earshoot				
7/29	1.7	1.1	0.4	...	...	...	...	...	...	...
8/1	6.6	5.0	2.1	4.9	2.6	63	50	62	33	26
8/4	20.0	14.5	2.1	18.3	9.3	185	100	59	85	40
8/8	39.2	35.6	2.0	46.0	27.8	225	204	41	238	185
8/11	62.1	56.5	4.4	54.4	31.8	213	207	75	238	231
	Percent K					Percent P				
8/1	1.40	1.41	1.64	1.37	1.49	0.77	0.76	0.71	0.82	0.67
8/11	0.77	0.94	1.95	0.86	0.90	0.48	0.45	0.69	0.45	0.57
	Percent Mg					Percent Ca				
8/1	0.19	0.18	0.17	0.19	0.17	0.16	0.16	0.13	0.17	0.13
8/11	0.14	0.11	0.17	0.13	0.13	0.10	0.10	0.15	0.09	0.11
	Fe, microgram/g earshoot					Zn, microgram/g earshoot				
8/1	44	52	43	50	48	40	52	37	45	38
8/11	44	48	51	45	53	34	30	37	26	32
	Mn, microgram/g earshoot					B, microgram/g earshoot				
8/1	36	34	31	36	27	17	17	16	18	17
8/11	15	15	38	15	19	15	15	19	15	17
	Percent reducing sugars					Percent sucrose				
8/1	36.8	42.5	33.5	...	...	10.0	0.3	2.9	...	...
8/4	30.9	35.8	35.8	...	...	15.9	15.2	4.1	...	...
8/8	21.8	20.5	35.4	...	...	5.8	10.2	2.4	...	...
8/11	11.3	13.9	21.9	14.4	23.3	9.4	9.3	4.5	16.9	13.5
	Percent total sugars					Nitrate, microgram/g earshoot				
8/1	46.5	42.8	36.2	...	...	88	93	133	...	...
8/4	46.2	50.3	39.7	...	...	36	32	258	...	...
8/8	27.2	30.2	37.7	...	...	0	14	299	....	...
8/11	20.1	22.6	26.1	30.2	36.3	157	217	446	12	33

[a] Normally nonfunctional under conditions of this experiment.

[b] Made functional by removal of first earshoots at their average date of silk emergence (as determined from check plants), July 29, 1955.

and third (nonfunctional) earshoots of the check plants on August 1. Ten days later, the concentrations of the elements showed a significant decrease in the first and second (functional) earshoots, probably because of the increase in earshoot weight. All eight elements showed virtually no change in concentration in the third (nonfunctional) earshoots. Mineral concentrations in the top three earshoots, therefore, afforded no explanation for the rapid growth and grain production of the first and second (functional) earshoots when the third (nonfunctional) earshoots were failing to grow and produce grain.

Removing the first (functional) earshoots July 29, which initiated rapid growth in the third (nonfunctional) earshoots, resulted in reduced concentrations of all elements except iron and boron measured in those third (now functional) earshoots on August 11, as compared with the third (nonfunctional) earshoots of the check plants. These lowered concentrations in the rapidly growing third (functional) earshoots apparently retarded the growth rate very little if at all.

On August 1, the first and second (functional) and the third (nonfunctional) earshoots had essentially the same nitrate level. During the 10-day sampling period, nitrate concentration increased significantly in the third (nonfunctional) earshoots but remained relatively low and variable in the first and second (functional) earshoots. Removing the first (functional) earshoots at silking resulted in a significantly reduced nitrate level in the rapidly growing third (now functional) earshoots by August 11. The failure of the third (nonfunctional) earshoots on the check plants to grow and produce grain may be related to their inability to reduce nitrates and synthesize protein more rapidly (Nodén and Thimann, 1963; Key, 1964; Oaks *et al.,* 1972).

The percent of reducing sugars in the upper three earshoots of L317 x R4 was relatively high on all dates sampled and was significantly higher in the third (nonfunctional) earshoots than in the first and second (functional) earshoots on August 8. The percent of reducing sugars decreased significantly in the first and second (functional) earshoots from August 1 to August 11 and in the third (nonfunctional) earshoots from August 8 to August 11. Removing the first earshoots to convert the third earshoots into functional earshoots decreased the concentration of reducing sugars in the third (now functional) earshoots from 33.5 percent on August 1 to 23.3 percent on August 11. During the same period, reducing sugars in the third (nonfunctional) earshoots of the check plants decreased from 33.5 percent to 21.9 percent. Milligrams of reducing sugars in the third (functional) earshoots actually increased from August 1 to August 11, though this is not immediately apparent because of the rapid increase in dry weight. Milligrams of reducing sugars remained approximately the same in the third (nonfunctional) earshoots during the period.

Within each group of first, second, and third earshoots sampled on each date, the percent of sucrose was very variable. Consequently, there was no significant difference between earshoots even though the average percent of sucrose was considerably higher in the first and second (functional) earshoots than in the third (nonfunctional) earshoots. Removing first earshoots July 29 resulted in a significantly higher concentration of sucrose in the third (now functional) earshoots than in the third (nonfunctional) earshoots of check plants on August 11.

Concentrations of IAA in the first and second (functional) and third (nonfunctional) earshoots of the check plants were similar on August 1. This level increased rapidly in the first and second earshoots from August 1 to August 8 but remained low in the third (nonfunctional) earshoots. Once again, the level of IAA in earshoots around silking time was not as accurate a criterion for differentiating between functional and nonfunctional earshoots as was dry weight. Removing the first (functional) earshoots at silking resulted in a rapid increase in IAA concentration and dry weight of the third (now functional) earshoots by August 11.

The relationship of weight and IAA concentration of functional earshoots of 2110 x 540 (Table 18) and L317 x R4 (Table 20) is similar to that of WF9 x Hy2, as studied by Maier (1954).

Avery *et al.* (1942), Wittwer (1943), Haagen-Smit *et al.* (1946), and Hinsvark *et al.* (1954) have reported a similar relationship between the concentration of IAA and the rate of growth of immature corn kernels of functional earshoots. The relationship between the concentration of IAA and rate of growth of apical and axillary buds of dicotyledonous plants has been reported by Thimann and Skoog (1934), Avery *et al.* (1936, 1937a), LeFanu (1936), Thimann (1937), and Van Overbeek (1938). These data show that both functional earshoots and apical buds of dicotyledonous plants have high concentrations of IAA; nonfunctional earshoots and axillary buds, on the other hand, have little or no IAA. Removing functional earshoots or apical buds at the proper time results in similar increases in IAA and growth of some of the upper previously nonfunctional earshoots and axillary buds; until clarified, this may be interpreted as cause and effect.

Growth of corn earshoots may be mediated by IAA, as proposed for growth of other plants by Skoog *et al.* (1942), Bonner (1949), Siegel and Galston (1953), Noodén and Thimann (1963), Key (1964), Key and Ingle (1964), Nitsan and Lang (1965), and Cheng (1972). These scientists associate growth of plant tissue with the involvement of auxins in the synthesis of esssential nucleic acids, proteins, and enzymes. On this basis, the failure of cobs and fertilized ovules of nonfunctional earshoots to grow normally may be due to a deficiency of auxins, a result of the dominance of the functional earshoots for these growth-promoting substances.

Respiration of earshoots

First and second (functional) earshoots of L317 x R4, planted July 1, 1957, and grown at one plant per 40" x 40" hill, were covered before silking. The first (functional) earshoots and the third (nonfunctional) earshoots that showed no signs of kernel development were harvested several times over a four-week period, beginning at silking. In another set of these plants, the three upper earshoots were covered before silking and the first (functional) earshoots were removed at silking; the rapidly growing third (now functional) earshoots were harvested several times over a four-week period. Randomly selected earshoots were brought quickly from the field to the laboratory, and dry weight, percent protein nitrogen, and rate of respiration of fresh samples were measured.

The first (functional) earshoots rapidly increased in fresh and dry weight and in milligrams of protein nitrogen but decreased in percent water and percent protein nitrogen (Table 21). The third (nonfunctional) earshoots showed an increase in fresh and dry weight, milligrams of protein nitrogen to August 7, and percent water, and showed a decrease in percent protein nitrogen less than that of the first earshoots. The failure of third (nonfunctional) earshoots to grow into functional earshoots thus appears to be due neither to a breakdown in protein synthesis nor to a deficiency of water.

The rate of respiration per unit of protein nitrogen throughout the sampling period was only slightly higher for first (functional) earshoots than for third (nonfunctional) earshoots of the check plants despite the great difference in the rate of increase in dry weight and in milligrams of protein nitrogen. The rate of respiration of the first (functional) and the third (nonfunctional) earshoots increased in the presence of 2,4-dinitrophenol (DNP); the third earshoots' increase was greater.

Removing the first (functional) earshoots at silking (July 31) resulted in a rapid rise in fresh and dry weight and in milligrams of protein nitrogen in the third (now functional) earshoots by August 2 and 5, and a decrease in percent water and percent protein nitrogen. There was also a rapid rise in the rate of respiration of the third (now functional) earshoots; adding DNP produced little additional increase in rate of respiration. It appears unlikely, therefore, under the conditions of this experiment, that the failure of the third (nonfunctional) earshoots to develop normally into functional earshoots is due to a deficiency of respiratory materials.

THEORY OF EARSHOOT DEVELOPMENT

The mechanism that controls the pattern of earshoot development and the number of ears per plant initiates and supports the growth of all earshoots basipetally to a potentially functional stage, whereupon one or more of the earshoots continue to develop basipetally into functional earshoots. The number depends on interaction of hybrid, planting rate, and cultural conditions.

Based on data presented in this publication and on the data of Freeman (1940), Sass and Loeffel (1959), Sass (1960, 1962), Collins (1963), Collins and Russell (1965), and particularly Siemer (1964) and Siemer *et al.* (1969), a working theory for such a mechanism is proposed as follows: The number of functional earshoots (ears) per plant of all hybrids depends upon genetic programing of the interval of time between initiation of the first and the lower earshoots per plant, as influenced by rate of planting and cultural conditions. Existence of this time interval permits establishment of differential rates of polar transport of growth-promoting substances and nutrients into the earshoots. These growth-promoting substances and nutrients regulate the rate and pattern of earshoot development and the number of functional earshoots per plant. The volume of polar transport of growth-promoting substances and nutrients increases into the earlier-initiated earshoots, which grow rapidly and become functional. The later-initiated earshoots receive a decreased amount of such substances and remain nonfunctional, although some grow to the silking stage.

Accordingly, there should be less time between initiation of the first and the second earshoots of a two-ear hybrid than between the first and the third earshoots; also, the first and second earshoots should presumably develop at about the same rate — and faster than the third earshoot. Similarly, there should be a longer interval between initiation of the first and the second earshoots of a one-ear hybrid than between the first and the second earshoots of a two-ear hybrid.

Table 21. Weight, Protein Nitrogen, and Respiration of First and Third Earshoots of L317 x R4, 1957 (One Plant per 40" x 40" Hill)

Date harvested	Fresh weight, g/earshoot			Percent water of earshoot			Dry weight, g/earshoot			Percent protein-nitrogen of earshoot		
	1[a]	3[a]	3[b]	1[a]	3[a]	3[b]	1[a]	3[a]	3[b]	1[a]	3[a]	3[b]
7/31	9.9	3.3	...	88.6	88.5	...	1.15	0.38	...	2.40	4.03	...
8/2	...	...	4.8	...	...	88.1	...	...	0.57	...	...	3.18
8/5	...	...	9.9	...	...	87.7	...	...	1.22	...	...	2.02
8/7	53.6	8.1	40.6	88.6	89.5	88.7	6.1	0.87	4.6	1.85	2.60	...
8/14	150.0	7.2	84.2	85.2	91.0	85.2	22.0	0.66	12.5	1.15	1.59	...
8/21	132.0	6.8	136.7	85.0	91.3	85.0	19.7	0.59	20.5	0.92	1.28	...
8/28	138.0	7.1	132.4	83.1	91.1	83.2	23.4	0.64	22.3	0.86	1.34	...

	Protein nitrogen, mg/earshoot			Microliter O_2/hour/mg protein-nitrogen								
				Check			DNP			Ratio DNP/check		
	1[a]	3[a]	3[b]	1[a]	3[a]	3[b]	1[a]	3[a]	3[b]	1[a]	3[a]	3[b]
7/31	28	15	...	185	144	...	193	159	...	1.04	1.10	...
8/2	...	...	18	...	...	220	...	...	229	...	...	1.04
8/5	...	...	25	...	...	227	...	...	155	...	...	1.12
8/7	113	23	...	187	155	...	247	239	...	1.32	1.54	...
8/14	253	10	...	212	202	...	282	373	...	1.33	1.85	...
8/21	181	7	...	149	144	...	314	342	...	2.11	2.37	...
8/28	201	9	...	194	179	...	365	398	...	1.88	2.22	...

[a] First (functional) and second (functional) earshoots were covered before silking to prevent pollination, and the first (functional) and the third (nonfunctional) earshoots were harvested on the dates given.

[b] First (functional), second (functional), and third (nonfunctional) earshoots were covered before silking. The first (functional) earshoots were removed on July 31 (average silking date), and the third (now functional) earshoots were harvested on the dates given.

Rate of planting and cultural conditions apparently would influence the pattern of earshoot development and the number of ears per plant by influencing the interval between initiation of earshoots. Otherwise, at different rates of planting and under different cultural conditions, multiple-ear hybrids would still produce the same number of ears per plant, and only the size of the ears would be affected.

It is unlikely that the number of ears per plant is the result of genetic control of the quantity or kind of growth-promoting substances synthesized by each plant or each earshoot or the result of morphological differences in the vascular system from the stalk to the earshoots (Gardner, 1925; Snow, 1925; Martin and Hershey, 1934; Moreland, 1934). As Van Overbeek (1938) and Gregory and Veale (1957) point out, however, the failure of axillary buds of pea plants to grow may be due to high concentrations of auxin in the stems; this may prevent normal development and use of the provascular strands that connect the buds to the main bundles of the stele, thus depriving the buds of adequate nutrients. Decapitation of pea seedlings results in a decrease in auxin concentration in the stems, an enlargement of the vascular system from the stem to the axillary buds, and an increase in auxin content of axillary buds before the buds start growing rapidly.

Corn also appears to show a lag in the rate of growth of third (nonfunctional) earshoots upon removal of first (functional) earshoots, as compared to the rate of growth of the functional earshoots of the check plants (Table 20). This seems to indicate that, like peas, enlargement of the vascular system of the third (nonfunctional) earshoots and an increase in growth-promoting substances are required before rapid growth can occur.

Three basic questions on earshoot development remain unanswered:

1. How many days are required for ovules on the first earshoot to become functional after they are initiated?
2. What are the differences between functional and nonfunctional ovules?
3. How does removal of the first (functional) earshoot before silking to a few days after silking mediate the conversion of nonfunctional ovules of lower earshoots into functional ovules?

Further research is needed on all three topics, but a possible explanation for the third can be proposed in terms of the dominance of functional earshoots over nonfunctional earshoots.

Dominance of functional earshoots over nonfunctional earshoots

When functional earshoots are removed from corn plants during a period from before silking of the top earshoot to a few days after, growth and grain production are stimulated in one or more of the nonfunctional earshoots. This phenomenon is interpreted as a "dominance effect" of the upper functional earshoots over the development of the lower nonfunctional earshoots, similar to the "dominance effect" of the apex of dicotyledonous plants over the development of the axillary buds. Inhibition of growth of lower axillary earshoots and of axillary buds of dicotyledonous plants increases basipetally in relation to their distance from the functional earshoot or from the apex (Harvey, 1920; Snow, 1925 and 1937; Thimann and Skoog, 1933 and 1934; Skoog and Thimann, 1934; LeFanu, 1936; Thimann, 1937; McIntyre, 1965). These authors generally agree that dominance of the apex over the growth of the lateral buds is mediated directly or indirectly by auxin from the apex.

Wickson and Thimann (1958) stated, "Although it is more than 20 years since it was shown that apical dominance of dicotyledonous plants is mediated by auxin, the method by which this is brought about remains obscure. None of the nine or so theories [proposed to explain apical dominance] has been definitely supported, and a fresh approach to the problem is called for." Essentially the same statement was made by McIntyre (1964) after about 30 years of investigation by many scientists into the mechanism of apical dominance.

In corn plants, dominance of functional earshoots over nonfunctional ones is believed to be a secondary effect rather than a primary cause. As already mentioned, the interval of time between initiation of the first and the lower earshoots is believed to be the first step in determining the number of functional and nonfunctional earshoots per plant.

Competition by the earshoots for growth-promoting substances and nutrients from the upper part of the plant favors growth of the earlier initiated upper earshoots, which become functional, and promotes growth of the later initiated lower earshoots, which remain nonfunctional, according to the interval of time between initiation of the upper and the lower earshoots. Dominance of functional earshoots over the growth of lower nonfunctional earshoots, therefore, is believed to be due to the "sink" provided by the functional earshoots for growth-promoting substances and nutrients, which deprives the nonfunctional earshoots of these substances. This type of dominance appears to be only "positional dominance," which has no influence in determining the number of nonfunctional earshoots per plant but does have a direct influence in keeping them nonfunctional by depriving them of growth-promoting substances.

The production of only one ear per plant by multiple-ear hybrids at high rates of planting or under conditions of artificial shading could also be interpreted as resulting from increased dominance of the top functional earshoot over development of the lower earshoots, according to current theories on apical dominance. If this were so, the increased dominance of the top functional earshoot over growth of the lower earshoots at high rates of planting would be inversely related to the quantity of growth-promoting substances produced by the plants. This is based on the assumption that a smaller plant at high rates of planting produces less growth-promoting substances than a large plant at low rates of planting. A more likely explanation, however, for the apparent increased dominance of the first earshoot over growth of the lower earshoots of multiple-ear hybrids at high rates of planting is an increase in the interval of time between initiation of the first and the lower earshoots. This early growth period gives the first earshoot a superior competitive position for receiving growth-promoting substances from the plant.

McIntyre (1964) suggested that dominance of the apex of dicotyledonous plants over growth of lateral buds may be related to the interval of time between initiation of the stem apex and the lateral buds. He stated that the earlier-initiated apex could well have sufficient initial advantage in competing for nutrients to account for the dominance it later achieved over lateral bud development as the pattern of growth became established.

The increasing basipetal inhibition of growth of the nonfunctional earshoots seems to negate the theory that the functional earshoots inhibit the growth of the nonfunctional earshoots by synthesizing and releasing auxins down the stalks. If the auxin production theory were correct, inhibition of the growth of nonfunctional earshoots should be the same or should decrease basipetally rather than increase basipetally, as is the case.

The mechanism by which functional earshoots maintain dominance over lower nonfunctional earshoots may be similar to one of the several ways suggested for the dominance of apical buds over the growth of lateral buds on dicotyledonous plants. These include competition for or mediation by the following substances:

1. Indoleacetic acid (Skoog and Thimann, 1934; Thimann and Skoog, 1934; LeFanu, 1936; Snow, 1937; Van Overbeek, 1938; Stuart, 1938; Skoog *et al.*, 1942; Leopold and Guernsey, 1953; Jacobs, 1961; Thompson and Jacobs, 1966).
2. Gibberellic acid, kinetin, ethylene, and abscisic acid (Wickson and Thimann, 1958; Sachs and Thimann, 1964; Jacobs and Case, 1965; Burg and Burg, 1966 and 1967; Davies *et al.*, 1966; Scott *et al.*, 1967; Pratt and Goeschl, 1969; Badr *et al.*, 1970; Wareing and Rybeck, 1970).
3. Oxidases and inhibitors (Tang and Bonner, 1947; Newcomb, 1951; Gortner and Kent, 1953; Galston and Dalberg, 1954; Maier, 1954; Goldsmith, 1968; Ockerse and Waber, 1970; Basu and Tuli, 1972; Beyer, 1972).
4. Nutrients (Gardner, 1925; Snow, 1925; Moreland, 1934; Avery *et al.*, 1936 and 1937a; Gustafson and Houghtaling, 1939; Mitchell, 1953; Gregory and Veale, 1957; McIntyre, 1964 and 1965).

SUMMARY

Approximately eight of the lower nodes of the corn plant usually have an axillary vegetative bud that is initiated acropetally and transformed into an earshoot in basipetal sequence. The earshoots that become functional also develop basipetally on the plants — always in sequence, never mixed randomly with nonfunctional earshoots. Also, the grain yield per ear of multiple-ear plants decreases from the top ear downward.

The uppermost earshoot, the first one to be initiated, apparently has no influence on the transformation of lower axillary buds into earshoots or on the number of earshoots per plant that become functional. Rather, the number and size of ears per plant are affected by the interaction of hybrid (genetics), rate of planting, and cultural conditions. Similarly, the same interaction of factors is thought to regulate the interval of time between initiation of the first and the lower earshoots in determining the number of functional and nonfunctional earshoots per plant. The number of functional and nonfunctional earshoots per plant, therefore, appears to be inherited on a quantitative rather than qualitative basis.

Upper earshoots that become functional have a direct role in keeping lower earshoots nonfunctional by depriving them of growth-promoting substances. Functional earshoots are dominant over the development of the lower nonfunctional earshoots by virtue of their earlier initiation and faster development. This dominance, which increases basipetally, is believed to result from the "sink" provided by functional earshoots for growth-promoting substances, rather than from production of any growth-inhibiting substances, including high concentrations of growth-promoting substances, synthesized or mediated by the functional earshoots. (A high concentration of growth-promoting substances in the stems of some dicotyledonous plants synthesized or mediated by apical buds is one suggested mechanism for dominance of apical buds over the growth of axillary buds.) However, the similarity between the dominance of functional earshoots over the growth of nonfunctional earshoots and the dominance of apical buds over the growth of axillary buds suggests a similar mechanism of control.

Nonfunctional earshoots develop into potentially functional earshoots, but their ability to become functional decreases with age, as demonstrated by the effects of removing functional earshoots at different times after silking.

Functional earshoots of multiple-ear plants develop at about the same rate, silking and being pollinated within about two days of each other. Nonfunctional earshoots develop at a slower rate than the functional earshoots, and nonfunctional earshoots that do silk usually do so about two to four days later than the uppermost functional one. Simultaneous pollination of all silking earshoots produces no more ears per plant than natural pollination. Earshoots that do not grow beyond the silk stage may have their ovules fertilized but produce little or no grain.

Pollination of the functional earshoots a few days before pollination of nonfunctional earshoots (the result of earlier silking) is not the cause for the failure of the nonfunctional earshoots to produce grain. The ability of the two functional earshoots of L317 x R4, for example, to produce grain is not impaired by pollinating either earshoot six days earlier than the other, although the earshoot that is pollinated earlier produces more grain.

Multiple-ear production requires more than proximity of silking of earshoots on a plant.

The main differences between the first (functional) and the third (nonfunctional) earshoots of L317 x R4 10 to 28 days after silking are that the nonfunctional earshoots have lower fresh and dry weights, slightly lower respiration rates, and lower concentrations of indoleacetic acid and sucrose, and higher concentrations of water, nitrates, and protein nitrogen. Removing the first (functional) earshoots of L317 x R4 at silking results in a rapid increase in fresh and dry weight, rate of respiration, and protein nitrogen, and a decrease in concentration of water, most minerals, and nitrates in the third (now functional) earshoots.

Three treatments can convert upper nonfunctional earshoots into functional earshoots:

1. Covering functional earshoots of certain hybrids before silking to prevent pollination.
2. Removing functional earshoots during the days just before silking to a few days after silking.
3. Shading plants 90 percent for six days just before silking.

Covering either of the two functional earshoots of L317 x R4 before silking stimulates an increase in grain yield by the other functional earshoot to a greater extent than removing either earshoot. Covering a functional earshoot does not stimulate grain production by the third (usually nonfunctional) earshoot nearly as much as removing either functional earshoot. Covering or removing nonfunctional earshoots before silking of the functional earshoots has no stimulatory effect on grain production of the functional earshoots.

The small and inconsistent stimulation to nonfunctional earshoots when functional earshoots are covered before silking probably results from reducing the size of the "sink" the functional earshoots provide for growth-promoting substances and nutrients. Conversely, the large and consistent stimulation received by nonfunctional earshoots when functional earshoots are removed before silking to a few days after silking apparently results from removing the "sink" for growth-promoting substances and nutrients.

Maximum stimulation of the uppermost nonfunctional earshoots to grow and to produce grain occurs when the functional earshoots are removed one to three days before their silking and one to two days before silking of the uppermost nonfunctional earshoots. Maximum stimulation of all nonfunctional earshoots to produce grain occurs when the functional earshoots and the uppermost nonfunctional earshoots are removed shortly before silking of the first functional earshoot. There is little or no stimulation of nonfunctional earshoots when the functional earshoots are removed about eight days after silking.

Rapidly growing pollinated and unpollinated functional earshoots have essentially the same concentration of indoleacetic acid 10 days after pollination, but only the pollinated earshoots contain a growth-promoting substance that is physiologically active in the split-pea curvature test, presumably in the developing kernels. Apparently, cobs and kernels require different growth-promoting substances for their development. Pollinated nonfunctional earshoots show no activity in the split-pea curvature test and do not fulfill the growth requirements of kernel development.

The mechanism that controls earshoot development in corn allows all earshoots to grow to a potentially functional stage, whereupon one or more of the earshoots develop basipetally into functional earshoots, the number depending upon hybrid, rate of planting, and cultural conditions. In such a mechanism, the number of functional and nonfunctional earshoots could be controlled by the genetic programing of the interval of time between initiation of the first and the lower earshoots, as influenced by rate of planting and cultural conditions. The interval of time between initiation of the first and the lower earshoots could establish differential rates of polar transport of growth-promoting substances and nutrients into the earshoots. The concentration of these substances and nutrients would in turn regulate the rate and pattern of earshoot development.

APPENDIX: INFLUENCE OF SYNTHETIC GROWTH-REGULATING CHEMICALS ON EARSHOOT DEVELOPMENT

The inhibitory effect of functional earshoots on the growth of nonfunctional earshoots appears to be analogous to the inhibitory effect of the terminal bud of dicotyledonous plants on the development of axillary buds into branches. Both of these inhibitory effects seem to involve growth-regulating compounds. To determine the effect on the development of uncovered functional and nonfunctional earshoots, several growth-regulating chemicals were applied to different parts of the corn plant around silking time (Lyons, 1952).

Five hybrids were planted May 16, 1951, and grown at one plant per 40" x 40" hill. Lanolin-paste mixtures of several growth-regulating chemicals were prepared in different concentrations, stored in a refrigerator, and taken to the field packed in ice to maintain a solid state for ease of application.

There were two sets of control plants. The first set received only a mechanical injury, such as removing an earshoot from a shank and cutting the internode and shank; the second set received the mechanical injury plus the proper amount of pure lanolin. The experimental plants were treated before silking and four times thereafter at six-day intervals. Immediately after earshoot removal, lanolin and lanolin mixtures of the various test chemicals were applied to shank stumps, bases of the shanks of earshoots, and stalk internodes.

Shank stump applications

To determine whether the inhibitory effect of functional earshoots could be replaced by growth-regulating chemicals, various chemicals were applied to the top surface of shank stumps according to the procedure previously described. At concentrations of 0.3 percent, none of six chemicals applied to shank stumps of the first (functional) earshoots of WF9 x Hy2 (one-ear hybrid) inhibited development of the second (nonfunctional) earshoots or stimulated development of lower nonfunctional earshoots (Table 22).

Two-percent mixtures of indoleacetic acid (IAA), of α-napthalene-acetic acid (NAA), and of 2, 3, 5-triiodobenzoic acid (TIBA) and 3-percent mixtures of IAA and of *p*-chlorophenoxyacetic acid (CPAA) were also applied to shank stumps of the first (functional) earshoots of WF9 x Hy2 (Table 22). These applications also had no inhibitory effect on the development of the second (nonfunctional) earshoots into functional earshoots and no stimulatory effect on the development of lower nonfunctional earshoots. Three-percent mixtures of IAA and of CPAA, however, caused extreme stalk curvature at the point of application. Applying 2-percent mixtures of IAA and of TIBA to the shank stumps of both the first (functional) and second (nonfunctional) earshoots reduced the size of the third ears, and the IAA mixture in this case stimulated grain development in some of the lower earshoots.

Several growth-regulating chemicals were also applied to shank stumps of 2110 x K64 and 2110 x Oh7 (two ears per plant) and 2110 x 540 (three ears per plant) at a concentration of 1 percent after the first (functional) or the first and second (functional) earshoots were removed (Table 23). With the possible exception of NAA and γ-phenylbutyric acid (PBA) applied to 2110 x 540, these chemicals had no inhibitory effects on the development of the upper nonfunctional earshoots into functional earshoots. There was little stimulation of lower nonfunctional earshoots to develop into functional earshoots.

It is reasonable to conclude that none of these growth-regulating chemicals substituted for the functional earshoots in inhibiting the development of the upper nonfunctional earshoots. Either the concentrations of these chemicals were incorrect; or they did not move basipetally through the shank and stalk to the lower earshoots; or they are not, in fact, the inhibitory agents mediated by functional earshoots in preventing growth of the nonfunctional earshoots.

These results with IAA are similar to those of Jacobs *et al.* (1959) and Davies *et al.* (1966), which showed that 1-percent IAA applied to decapitated stems of coleus and bean plants did not replace the inhibitory effect of the apical bud on the growth of lateral branches. Hoffman (1953) also reported that, although CPAA inhibited auxin-controlled plant responses such as epinasty, swelling of stems, negative geotropism of stems, orientation of stems to light, and rooting of cuttings, it did not replace the inhibitory effect of the terminal bud on the growth of axillary buds of tomato plants. On the other hand, Skoog and Thimann (1934), Thimann and Skoog (1934), Thimann (1937), and Link and Eggers (1946) showed that IAA applied to decapitated stems of *Vicia faba* and flax replaced the inhibitory effect of the apical bud on the growth of axillary buds. Klein and Link (1948) reported that 75 ppm of 2,4-dichlorophenoxyacetic acid (2,4-D) applied to tips of decapitated flax stems also inhibited axillary bud development.

Shank-base application

From the base of each shank a notch of tissue was removed, and a lanolin-chemical mixture was applied in the notch. To find out whether and to what extent the growth of attached earshoots and of earshoots above and below the treated shanks would be affected, growth-regulating chemicals were applied to 2110 x K64 (two ears per plant) and 2110 x 540 (three ears per plant), according to the procedures previously described.

Applying 1 percent of IAA or of TIBA to the bases of the shanks of the three functional earshoots of 2110 x 540 resulted in the development of small, deformed ears and some stimulation of the lower nonfunctional earshoots (Table 24). Treating the shanks of the upper six earshoots of this hybrid a few days later with either chemical did not appreciably affect the normal earshoot pattern. Apparently, the stage of development of the earshoots at the time of application influences the results of this treatment. This is similar to the effects of letting some time elapse between decapitating dicotyledonous plants and applying auxin to the tip of the stem in inhibiting growth of lateral buds (Wickson and Thimann, 1958).

Applying IAA to the bases of the shanks of the fourth and fifth (nonfunctional) earshoots neither stimulated their development nor adversely affected the development of the three functional earshoots.

Applying 1-percent PBA or 2-percent TIBA to the bases of the shanks of the three upper earshoots of 2110 x K64 (two ears per plant) had no observable effect on earshoot development (Table 25), whereas 1 percent of TIBA applied to the bases of the shanks of the three functional earshoots of 2110 x 540 had severely affected their development (Table 24). Three-percent CPPA, however, applied to 2110 x K64 caused development of parthenocarpic-type kernels (empty, lacking an embryo, nonviable) on the first and second (functional) earshoots and stimulated no ear development of the nonfunctional earshoots (Fig. 18).

On the basis of these data it may be assumed that IAA, TIBA, and CPAA moved acropetally through the shanks of functional and nonfunctional earshoots, adversely affecting the growth of some of the functional earshoots but failing to stimulate much growth of the nonfunctional earshoots. Acropetal movement of IAA through sections of dicotyledonous plants has been confirmed by Jacobs (1954) and Naqvi and Gordon (1965).

Table 22. Response of WF9 x Hy2 (One Ear per Plant) to Growth-Regulating Chemicals Applied to Shank Stumps From Which Earshoots Have Been Removed

Treatment	Plant	Ears developed 2	3	4	5	6	7	8
		First earshoot removed						
None	1	x	-					
	2	x	-					
	3	x	x					
	4	x	-					
	5	x	-					
Lanolin alone	1	x	-					
	2	x	-					
	3	x	-					
	4	x	-					
	5	x	-					
0.3% IAA	1	x	-					
	2	x	-					
	3	x	-					
	4	x	-					
	5	(plant broke over)						
2.0% IAA	1	x	-	-	e	e	e	
	2	x	-	-	-	-	-	
	3	x	-	-	-	-	-	
	4	x	(plant broke over)					
	5	x	e	-	e	e	e	
3.0% IAA[b]	1	x	-	-	-	-	-	
	2	x	-	-	-	-	f	
	3	x	-	-	-	-	-	
	4	(broke over)			-	-	-	
	5	(broke over)			-	-	-	
0.3% indole-butyric acid	1	x	-					
	2	x	-					
	3	x	-					
	4	x	-					
	5	x	-					
0.3% NAA	1	x	-	-	-	-		
	2	x	-	-	-	s		
	3	x	m	-	-			
	4	x	-					
	5	x	-					
2.0% NAA	1	x	-	-	-	-	-	-
	2	x	e	-	-	-	e	e
	3	x	e	-	-	e	-	-
	4	x	e	-	-	-	-	-
	5	(plant broke over)						
		First earshoot removed						
0.3% CPAA	1	x	-					
	2	x	-					
	3	x	-	v	-			
	4	x	-	-	-	v		
	5	x	-	-	-	-		
3.0% CPAA[a]	1	x						
	2	x						
	3	x						
	4	x						
	5	x						
0.3% PBA	1	x	-					
	2	x	-					
	3	x	-	v	-			
	4	x	-	-	-	v		
	5	x	-	-	-	-		
0.3% TIBA	1	x	-					
	2	x	-					
	3	x	-					
	4	x	-					
	5	x	-					
2.0% TIBA	1	x	-					
	2	x	-					
	3	x	-					
	4	x	-					
	5	x	-					
		First and second earshoots removed						
None	1		x	-	-	s	s	-
	2		x	f	s	s	-	-
	3		x	-	-	s	v	v
	4		x	-	-	s	v	
	5		x	-	s	s	s	
2.0% IAA	1		m	m	m	e	m	m
	2		m	m	f	f	f	-
	3		m	m	s	s	s	-
	4		m	m	m	m	-	-
	5		m	s	s	-	-	-
2.0% TIBA	1		m	-	(broke over)			
	2		m	f	f	f	f	f
	3		m	-	(broke over)			
	4		m	f	f	-	f	
	5		(plant broke over)					

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[a] All plants broke over at the point of application within 24 hours of application.
[b] Extreme curvature of all plants.

KEY:
x = normal size ear
m = medium size ear
s = small ear
v = very small ear
- = no ear developed
f = few kernels present
e = enlarged shoot, no grain

Table 23. *Responses of Several Hybrids to Growth-Regulating Chemicals Applied to Shank Stumps From Which Earshoots Have Been Removed*

Treatment	Plant	2110 x K64[a] Ears developed 2	3	4	5	6	7	8
None	1	x	x	-				
	2	x	x	-				
	3	x	x	-				
	4	x	x	-				
	5	(plant broke over)						
Lanolin	1	x	x	-				
	2	x	x	-				
	3	x	x	-				
	4	x	x	-				
	5	x	x	-				
1% IAA	1	x	x	m				
	2	x	x	-				
	3	x	x	-				
	4	x	x	s				
	5	x	x	-				
1% indole-butyric acid	1	x	x	m				
	2	x	x	-				
	3	x	x	-				
	4	x	x	-				
	5	x	x	-				
1% TIBA	1	x	x	-				
	2	x	x	-				
	3	x	-	-				
	4	x	x	s				
	5	x	x	-	-	-	-	x

Treatment	Plant	2110 x Oh7[a] Ears developed 2	3	4	5	6
None	1	x	x	-		
	2	x	x	-		
	3	x	x	-		
	4	x	x	v		
	5	x	x	-		
Lanolin	1	x	x	x		
	2	x	x	-		
	3	x	x	x		
	4	x	x	-		
	5	x	x	-		
1% IAA	1	x	x	-	s	
	2	x	x	-	-	
	3	x	x	-	-	
	4	x	-	-	(top broken out)	
	5	x	-	-	(top broken out)	
1% indole-butyric acid	1	x	x			
	2	x	x	-	-	m
	3	x	x	-	-	
	4	x	x	x		
	5	x	x	x		
1% TIBA	1	x	x			
	2	x	x	x	e	
	3	x	x	x	-	
	4	x	x	x	-	
	5	x	x	s	-	

Treatment	Plant	2110 x Oh7[b] Ears developed 3	4	5	6
None	1	x	x	x	
	2	x	x	(top out of plant)	
	3	x	x	x	
	4	x	x	m	
	5	x	x	-	
Lanolin	1	x	x	x	
	2	x	x	m	
	3	x	x	-	
	4	(plant broke over)			
	5	(plant broke over)			
1% IAA	1	x	x	x	
	2	x	x	-	
	3	x	x	-	
	4	x	x	-	
	5	(plant broke over)			
1% indole-butyric acid	1	x	x	-	-
	2	x	x	x	-
	3	x	x	s	s
	4	(top out of plant)			
	5	x	x	x	
1% TIBA	1	x	x	s	
	2	x	x	(top broken out)	
	3	x	e	-	
	4	x	x	x	
	5	x	x	e	
1% NAA	1	x	x	-	
	2	x	x	-	
	3	x	x	-	
	4	x	x	s	
	5	(top broken out)			

Treatment	Plant	2110 x 540[c] Ears developed 2	3	4	5	6	7
None	1	x	x	x	-		
	2	x	x	x	-		
	3	x	x	x	-		
	4	x	x	x	x		
	5	x	x	s	s		
Lanolin	1	x	x	x	-	-	
	2	x	x	x	-	-	
	3	x	x	-	-	-	
	4	x	x	-	-	m	
	5	x	x	x	-	-	
1% IAA	1	x	x	x	-	-	
	2	x	x	s	-	-	
	3	x	x	x	m	v	v
	4	x	x	x	m	-	-
	5	x	x	x	-	-	-
1% indole-butyric acid	1	x	x	m	x		
	2	x	x	m	-		
	3	x	x	x	-		
	4	x	x	-	x		
	5	x	x	-	x		
1% TIBA	1	x	x	x	s	-	
	2	x	x	x	m	-	
	3	x	x	s	x	-	
	4	x	x	s	x	x	
	5	x	x	x	-	-	
1% NAA	1	x	x	-	-	-	
	2	x	s	-	s	s	
	3	x	x	-	s	-	
	4	x	x	(top broken out)			
	5	x	x	(top broken out)			
1% PBA	1	x	x	-	s	-	
	2	x	x	-			
	3	x	x	-	-	f	
	4	x	x	-	(top out)		
	5	x	x	x	-		
1% CPAA	1	x	x	-	v		
	2	x	x	x	-		
	3	x	x	x	x		
	4	x	x	x	-		
	5	x	x	-	-		

[a] Two-ear hybrid, first earshoot removed.
[b] Two-ear hybrid, first and second earshoots removed.
[c] Three-ear hybrid, first earshoot removed.

KEY:
x = normal size ear
- = no ear developed
m = medium size ear
s = small ear
v = very small ear
f = few kernels present
e = enlarged shoot, no grain

Stalk internode application

Two vertical slits approximately 5 mm apart and 9 to 10 mm long were cut in the outer layer of each selected stalk internode. This strip of tissue was cut loose from underlying tissue but left intact at both ends. Lanolin-chemical mixtures in concentrations previously indicated were applied with a spatula to the tissue under the loose strip.

Table 24. Response of 2110 x 540 (Three Ears per Plant) to Growth-Regulating Chemicals Applied to the Bases of Shanks of Earshoots

Treatment	Plant	Ears developed 1	2	3	4	5	6	7	8
		Earshoots 1, 2, and 3 treated							
Shanks slit only	1	x	x	x	-	m			
	2	x	x	x	-				
	3	x	x	x	-				
	4	x	x	x	-				
	5	x	x	x					
Lanolin	1	x	x	x	-	-			
	2	x	x	-					
	3	x	x	x					
	4	x	x	x	-				
	5	x	x	-	-	m			
1% IAA	1	c	c	d	-	x			
	2	c	c	-	m	m			
	3	c	x	-	-	-			
	4	c	c	x	-	-			
	5	c	c	x	-	-			
1% TIBA	1	c	d	c	x	-			
	2	c	c	d	-	v			
	3	x	x	v	x	-			
	4	c	c	v	-	v	f	e	e
		Earshoots 1 through 6 treated							
1% IAA	1	x	x	x					
	2	x	x	x					
	3	x	x	x					
	4	x	x	x					
	5	x	x	x					
1% TIBA	1	x	x	-					
	2	x	x	-					
	3	x	x	x	e	-			
	4	x	x	x	e	e	e		
		Earshoots 4 and 5 treated							
1% IAA	1	x	x	x					
	2	x	x	x					
	3	x	x	x					
	4	x	x	x					
	5	x	x	x					

KEY:

x = normal ears
- = no ear developed
m = medium size ear
v = very small ear
e = enlarged shoot, no grain
f = few kernels present
c = small deformed ear
d = small deformed ear, no grain

Applying 2-percent IAA, NAA, or TIBA to the stalk internode above the first (functional) earshoots neither inhibited normal earshoot development nor stimulated development of the nonfunctional earshoots (Table 26). In WF9 x Hy2 and G-94, however, IAA and TIBA produced curvature of stalks at the point of application but did not so affect 2110 x 540. Three-percent CPAA produced stalk curvature and parthenocarpic-type kernels on WF9 x Hy2 and G-94. Applying 2-percent IAA to the stalk internode of WF9 x Hy2 and G-94 below the second (nonfunctional) earshoot neither stimulated development of the second earshoots nor inhibited development of the first (functional) earshoots.

Ethanol-aqueous applications. To determine whether a different method of application might prove more effective than the lanolin paste treatments in stimulating or inhibiting earshoot development, ethanol-aqueous solutions of a few growth-regulating chemicals were placed into the stalk internode above and below functional earshoots and into sheath cavities around functional and nonfunctional earshoots. The required amount of each chemical was dissolved in a few milliliters of 95-percent ethyl alcohol and made to volume with distilled water. The chemicals precipitated when the water was added, but most redissolved upon slight heating.

To get the solution of chemicals into the stalk internodes, a core about 2 cm long and 7 mm in diameter was cut from the internode with a cork borer at a downward angle of 45 degrees. A glass tube slightly larger than the

Table 25. Response of 2110 x K64 (Two Ears per Plant) to Growth-Regulating Chemicals Applied to the Bases of the Shanks of Earshoots 1, 2, and 3

Treatment	Plant	Ears developed 1	2	3	4	5
1% PBA	1	x	x	-		
	2	x	x	-		
	3	x	x	-		
	4	x	x	-		
	5	x	x	-		
2% TIBA	1	x	x	f		
	2	x	x	f		
	3	x	x	-		
	4	x	x	-		
	5	x	x	-		
3% CPAA	1	p	p	-		
	2	p	p	-		
	3	p	p	-		
	4	p	p	-		
	5	p	p	-		

KEY: x = normal ear
f = few kernels present
- = no ear developed
p = parthenocarpic-type kernels

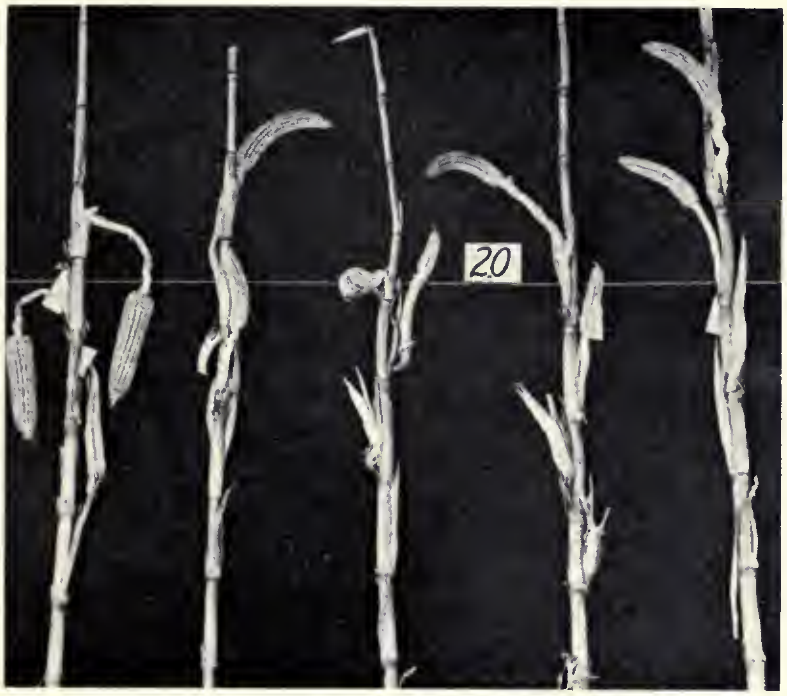

Figure 18. Parthenocarpic-type kernels that developed on the first and second (functional) earshoots of 2110 x K64 when 3-percent p-chlorophenoxyacetic acid was applied to the bases of the shanks of the upper three earshoots on the four plants to the right.

core and about 5 cm long was inserted in the internode as soon as the core was removed, and the upper end of the tube was plugged with cotton. The tube was placed in the internode above the first earshoot or below the lowest functional earshoot as soon as the earshoots became visible above the sheath. One-half ml of the chemical solution was injected from a hypodermic syringe through the cotton plug into the tube at three-day intervals for three weeks after insertion of the glass tubes.

Applying 1-percent TIBA or IAA into stalk internodes above or below the functional earshoots of 2110 x 540, 2110 x K64, and 2110 x Oh7 adversely affected only the development of the third (functional) earshoots of 2110 x 540. No nonfunctional earshoots were stimulated to develop on any of the three hybrids (Table 27).

In a variation of technique, a hypodermic syringe was used to inject the chemical solutions through the leaf sheath into the sheath cavity around an earshoot. Two ml of solution were injected into each sheath cavity at three-day intervals for three weeks, beginning with the emergence of the earshoots above the sheath. One percent of TIBA, IAA, or NAA, was injected into the sheath cavity around the first, second, and third (functional) earshoots of one set of plants and into the sheath cavity around the fourth and fifth (nonfunctional) earshoots of another set of plants of 2110 x 540.

Triiodobenzoic acid and IAA in the sheath cavities around the upper three functional earshoots adversely affected development of only the third earshoots, whereas NAA inhibited normal development of all three functional earshoots and caused extreme stalk curvature. Injecting the three chemicals into the sheath cavity around the fourth and fifth (nonfunctional) earshoots stimulated no growth in these earshoots but did adversely affect development of the third (functional) earshoots.

Gibberellic acid treatment

Spray applications of aqueous solutions of 10, 50, 100, and 200 ppm of potassium gibberellate have been applied to plants of WF9 x M14 and Hy2 x Oh7 at several stages of development (Cherry *et al.*, 1960). Heights of plants were increased but not number of ears per plant or yield of grain per acre.

Summary

Applying growth-regulating chemicals to various parts of corn plants may not stimulate growth of nonfunctional earshoots but can adversely affect development of some of the functional earshoots. For example, applying 3-percent CPAA to the bases of shanks of functional earshoots and to the stalk internodes above the top earshoots produces parthenocarpic-type kernels on the functional earshoots.

Data from this series of experiments show that the hybrid, the type and concentration of growth-regulating chemical, the stage of growth of the functional earshoots, and the part of the plant treated are important factors in determining the degree of response of earshoots to these chemicals. None of the growth-regulating chemicals tested replaced the inhibitory effect of functional earshoots on the development of nonfunctional earshoots nor stimulated development of nonfunctional earshoots. This neither substantiates nor rules out the possibility that the low concentration of growth-promoting substances in nonfunctional earshoots (Tables 18 and 20) may be the primary cause of their lack of growth, however, since the correct concentration of the synthetic growth-regulating chemicals necessary for growth may not have been attained or, if attained, may not have been the growth-promoting substances of earshoots.

Table 26. Responses of Several Hybrids to Growth-Regulating Chemicals Applied to Stalk Internodes

	WF9 x Hy2 (1-ear hybrid)				G-94 (1- and 2-ear hybrid)							2110 x 540 (3-ear hybrid)					
		Ears developed				Ears developed							Ears developed				
Treatment	Plant	1	2	3	Plant	1	2	3	4	5	6	Plant	1	2	3	4	5
Applied to stalk internode above top earshoot																	
Stalk slit only	1	x	x									1	x	x	x		
	2	x	-									2	x	x	x		
	3	x	m									3	x	x	s		
	4	x	-									4	x	x	x		
	5	x	s									5	x	x	m		
Lanolin only	1	x	m		1	x	-					1	x	x	x		
	2	x	-		2	x	-					2	x	x	x		
	3	x	-		3	x	-					3	x	x	x		
	4	x	-		4	x	s					4	x	x	x		
	5	x	-		5	x	-					5	x	x	s	x	
2% IAA	1[a]	x	-		1[b]	x	-					1	x	x	x		
	2[a]	x	m		2[b]	x	-					2	x	x	x		
	3[a]	x	-		3[b]	x	-					3	x	x	x		
	4[a]	x	-		4[b]	x	v					4	x	x	x		
	5[a]	x	-		5[b]	x						5	x	x	x		
2% NAA	1	x	-														
	2	x	-														
	3	x	-														
	4	x	-														
	5	x	-														
3% CPAA	1[b]	p	s		1[b]	p	-	-	e	e	e						
	2[b]	p	s		2[b]	p	-	-									
	3[b]	p	s		3[b]	p	-	-									
	4[b]	p	s		4[b]	p	p	-									
	5[b]	p	s		5[b]	p	f	-									
2% TIBA					1[c]	x	-					1	x	x	x		
					2[c]	m	m					2	x	x	x		
					3[c]	m	m					3	x	x	x		
					4[c]	x	v					4	x	x	s	-	x
					5[c]	x	-					5	x	x	x	-	-
Applied to stalk internode below second earshoot																	
Lanolin	1	x	-		1	x	v										
	2	x	s		2	x	-										
	3	x	-		3	x	x										
	4	x	x		4	x	x										
	5	x	-		5	x	-										
2% IAA	1	x	x		1	x	-										
	2	x	-		2	x	x										
	3	x	-		3	x	-										
	4	x	-		4	x	s										
	5	x	-		5	m	m										

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[a] Extreme stalk curvature away from point of application.
[b] Stalk curvature away from point of application.
[c] Sharp stalk curvature towards point of application.

KEY:
x = normal size ear
- = no ear developed
m = medium size ear
s = small ear
v = very small ear
f = few kernels present
e = enlarged shoot, no grain
p = parthenocarpic-type kernels

Table 27. Responses of Several Hybrids to Injections of Ethanol-Aqueous Solutions of Growth-Regulating Chemicals[a]

		1-percent TIBA				1-percent IAA				1-percent NAA			
			Ears developed				Ears developed				Ears developed		
Hybrid	Point of injection	Plant	1	2	3	Plant	1	2	3	Plant	1	2	3
2110 x 540 (three ears per plant)	Sheath cavities around 1st, 2nd, and 3rd ear-shoots	1	x	x	x	1	x	x	v	1[b]	-	v	-
		2	x	x	-	2	x	x	-	2[b]	-	-	-
		3	x	x	m	3	x	x	-	3[b]	x	s	-
		4	x	x	-	4	x	x	-	4[b]	v	v	-
		5	x	x	s	5	x	x	-	5[b]	v	v	-
	Sheath cavities around 4th and 5th earshoots	1	x	x	v	1	x	x	-	1	x	x	x
		2	x	x	-	2	x	x	x	2	x	x	-
		3	x	x	v	3	x	x	x	3	x	x	-
		4	x	x	v	4	x	x	-	4	x	x	x
		5	x	x	v	5	x	x	-	5	x	x	-
	Stalk internode above 1st earshoot	1	x	x	v	1	x	x	x				
		2	x	x	v	2	x	x	s				
		3	x	x	-	3	x	x	v				
		4	x	x	v	4	x	x	-				
		5	x	x	v	5	x	x	-				
	Stalk internode below 3rd earshoot	1	x	x	s								
		2	x	x	v								
		3	x	x	-								
		4	x	x	s								
		5	x	x	s								
2110 x K64 (two ears per plant)	Stalk internode above 1st earshoot	1	x	x	v								
		2	x	x	-								
		3	x	x	-								
		4	x	x	-								
		5	x	x	-								
2110 x Oh7 (two ears per plant)	Stalk internode below 2nd earshoot	1	x	x	-								
		2	x	x	-								
		3	x	x	-								
		4	x	x	v								
		5	x	x	-								

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[a] These experiments showed no earshoot development below the third earshoot.

[b] Extreme stalk curvature.

KEY: x = normal ear - = no ear developed m = medium size ear s = small ear v = very small ear

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